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Agricultural and Horticultural Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL,

1929.

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CONTENTS.

PAGE

INTRODUCTION .. .. *B. T. P. Barker* 7

FRUIT CULTURE :—

Progress Report on Fruit Breeding .. .. *G. T. Spinks* 12

Families of Strawberry Seedlings Bred for Resistance to Aphis .. .. *G. T. Spinks* 17

Self-Fertility and Self-Sterility in Cider Varieties of Apples .. .. *G. T. Spinks* 28

The Time of Differentiation of the Flower-Bud of the Apple .. *Margaret Gibbs and T. Swarbrick* 34

Root Regeneration upon Transplanted Apple Rootstocks .. *T. Swarbrick* 40

Pot Experiments on the Manuring of Fruit Trees :

V. The Effects of Deficiencies of Potassium, Calcium and Magnesium respectively on the Contents of these Elements and of Phosphorus in the Shoot and Trunk Regions of Apple Trees .. .. *T. Wallace* 47

Experiments on the Effects of Leaching with Cold Water on the Foliage of Fruit Trees :

I. The Course of Leaching of Dry Matter, Ash and Potash from Leaves of Apple, Pear, Plum, Black Currant and Gooseberry .. .. *T. Wallace* 59

The Shape and Quality of Apples in Relation to their Position in the Fruit Cluster—Progress Report .. *J. C. Hinton and T. Swarbrick* 67

PLANT PATHOLOGY :—

Investigations on Chlorosis of Fruit Trees :

IV. The Control of Lime-Induced Chlorosis in the Field .. .. *T. Wallace* 73

Further Observations on Pyrethrum Spray Fluid .. *F. Tutin* 93

Examination of Plants for Insecticidal Principles.—I. *F. Tutin* 96

The Common Green Capsid Bug (*Lygus pabulinus*) as a Pest of Sugar Beet .. .. *C. L. Walton and L. N. Staniland* 99

Tar-Distillate Washes as a Control for the Apple Capsid Bug : Field Experiments, 1929 .. .. .. *L. N. Staniland and C. L. Walton* 101

CONTENTS—*contd.*

PAGE

The Raspberry and Loganberry Beetle and its Control. Some Experiments with a Pyrethrum Emulsion Spray .. *C. L. Walton* 115

Experiments on the Control of Pear Midge (*Contarinia pyrivora*). Progress Report .. .. *L. N. Staniland and C. L. Walton* 124

Investigations on the Fungicidal Action of Sulphur : IV. Third Progress Report .. .. *B. T. P. Barker* 130

Observations on the Diseases of Market Garden Crops in the Vale of Evesham .. .. *L. Ogilvie* 149

Spraying Trials against Apple Scab : II. Season 1929 .. .. *J. G. Maynard and R. W. Marsh* 155

Supplementary Note on the Control of Black Currant Leaf Spot .. .. *R. W. Marsh and J. G. Maynard* 166

The Economics of Spraying Fruit Trees : II. The Cost of Summer and Winter Washing, 1929 and 1930 .. .. *J. G. Maynard* 168

CIDER :—

Cider Making Trials for the Season 1928-29 .. .. *O. Grove* 176

The Effects of Low Temperature Storage on Cider .. *B. T. P. Barker and O. Grove* 196

Some Trials with New Types of Cider Filters .. .. *O. Grove* 200

The Preparation of Willow Rods for Industrial Use by Decorticating Machinery and its Economic Significance.. *H. P. Hutchinson* 204

ADVISORY AND EDUCATIONAL SECTION :—

Report on Advisory Work, 1928-29 210

MISCELLANEOUS :—

Report on Ox Warble Flies and their Control .. *R. C. Gaut and C. L. Walton* 220

PUBLICATIONS DURING 1929 226

INTRODUCTION.

The following report on the work of the Long Ashton Research Station and its associated centres at Berkeley Square, Bristol, and Chipping Campden, which together constitute the Agricultural and Horticultural Departments of the University of Bristol deals principally this year with investigations carried out by members of the Long Ashton staff. For reasons of space it has been considered necessary on this occasion to reduce considerably the length of the usual reports on the advisory work of the Department.

There has been unusually little change during the year in the Department in respect of personnel, buildings or land development. As indicated in the last Annual Report, almost the whole of the land on the farm at Long Ashton suitable for field experiments has been planted with fruit, and there is no other available land appropriate for such purposes in the vicinity of the Station. Hence, for a time at least, it is unlikely that much further planting will be done except on plots becoming vacant through the completion of the experiments at present in progress thereon. While this situation exists, it will influence necessarily the nature of new work undertaken in the field, and will cause more to be done on outside fruit farms where suitable arrangements can be made. In this connection the Station warmly recognises the support of fruit growers in all the leading fruit districts. The readiness with which facilities for experiments on their farms have been provided and the active assistance and interest of the growers in such work where it has already been started have been most gratifying as well as invaluable in furthering fruit research.

Staff. Mr. A. N. Dunsby, B.Sc., a member of the Long Ashton chemical staff engaged on the fruit soil survey and related work since March, 1927, has resigned his post to take up a commercial appointment, and has been succeeded by Mr. L. G. G. Warne.

Mr. F. C. Lewis, B.Sc., from the Chemical Department of the University, has been appointed for a 2 year period to assist Mr. Tutin in the investigations which he has in hand. This appointment has been made possible by a donation to the Station from Imperial Chemical Industries, Ltd. This generous gift is particularly timely, in view of the important work which Mr. Tutin has in hand.

Miss K. H. Johnstone completed last September the two years' period of research on Apple Scab at the Station on which she has been engaged during the tenure of the Bathurst Research Studentship, awarded to her by Newnham College, Cambridge. She has now received an appointment under the Ministry of Agriculture and Fisheries.

At the Berkeley Square Advisory Centre, Mr. A. de M. Chesterman, student-assistant in the Agricultural Economics branch, has left to take a post at Cambridge University. Mr. G. G. Hayes has been appointed in his place.

Other Departments of the University have rendered very useful assistance on various subjects. Mr. H. G. H. Kearns, Lecturer in Zoology, is collaborating with the entomological staff of the Station in certain of the entomological investigations. Miss Margaret A. Gibbs of the Botanical Department, has been associated with Dr. Swarbrick in the work on Apple Fruit Bud Formation published in this Report. Mr. R. W. G. Dennis, of the same Department, has assisted Mr. Marsh in spraying trials and is still engaged on a mycological investigation in conjunction with him. Mr. N. Inward, B.Sc., also of the same Department, has in hand an investigation of the botanical characters of varieties of gooseberries for identification and classification purposes. Mr. J. H. Lees, B.A., of the Department of Physics, has been awarded a Special Investigation Grant by the Ministry of Agriculture and Fisheries for research in the physics of dust sprays.

Mr. M. B. Davis, B.S.A., Chief Assistant in the Canadian Horticultural Department, is making the Station his headquarters during a year's study leave in this country. Since his arrival he has been engaged on an investigation concerned with the nutrition of apple trees. The Station is fortunate in having this opportunity of establishing so close a link with the fruit industry in Canada.

Land and Plantations. At Long Ashton itself, as already mentioned, little has been done in the direction of new planting.

The third successive series of strawberry plants on the manurial plots has been established.

The raspberry variety trials have been extended by the addition of a number of fresh varieties to the trial plot.

Further batches of seedlings raised in the course of the fruit breeding work, have been planted out for preliminary trial, and various selections of promising sorts from the earlier batches have been propagated in suitable number and planted out for more exhaustive tests.

In the rootstock work further trees on the rootstocks selected by Mr. Spinks have been raised, and three new centres for trials have been established in various parts of the Bristol Province.

An addition to the existing series of trial cider orchards has been made by the establishment of a new orchard in Dorset.

General. The year 1929 has been notable in the history of the Station in seeing brought to the point of practical application two investigations of major importance to the fruit growers of this country. One of them in particular—that on the control of the Capsid bug pest of fruit trees by means of an egg-killing winter wash—has attracted the universal attention of growers in all districts afflicted with this insect pest, justly regarded as the most serious menace to English fruit culture of recent times. Thanks to special grants from the Ministry of Agriculture for the past three or four years, it has been possible for the Institute to concentrate on the problems of tar oil washes, with the result that a form of this type of spray fluid has been evolved which field trials in all the leading fruit growing areas in this country have now demonstrated beyond question to give a practically complete commercial control of the capsid pest. So convincing have been the results that some fifteen spray fluid manufacturing firms in the country are now placing on the market winter washes based on the Long Ashton formula, and firms of manufacturing chemists who have not hitherto been associated with spray fluid production have begun to make the Long Ashton wash. Reports already to hand show that during the 1929-30 winter spraying season at least two millions of gallons of washes prepared from such concentrates will be used in English fruit plantations and orchards.

The second of the two investigations referred to in the last paragraph is that concerned with the nutrition of fruit trees. The particular aspect of the subject which has come into prominence because of its practical application is the action of potash. Both the experiments at the Institute and the soil surveys in various fruit growing areas undertaken by the Staff have shown that the outstanding nutritional problem in fruit culture in this country results from potash deficiency in certain soils. In such cases the trees assume the condition known as leaf scorch ; they fall into a stagnant state of growth and quickly become valueless. Potash deficiency is sufficiently common in this country to have been already the cause of serious financial loss to many growers. The loss incurred has generally not been limited merely to that incidental to the planting and maintenance of unproductive plantations and orchards : the grower in an endeavour to force stagnant trees into growth has added to his losses by fruitless expenditure on the apparently obvious requirement of nitrogenous manures. The

Long Ashton experiments have demonstrated, firstly, that such treatment intensifies the trouble and may even initiate it in cases where the potash supply is near the critical point and, secondly, that the only remedy is to change radically the nature of the potash-nitrogen ratio in the plant by feeding with potash salts and reducing nitrogenous nutrients. This procedure has now been applied widely, many previously worthless plantations have been transformed into profitable holdings, and land hitherto useless for fruit production has been rendered suitable for that purpose. By means of local field trials, lectures and show exhibits, that knowledge has been widely dispersed among the English fruit growers and its practical application is rapidly extending.

In other directions also there is abundant evidence that the work of the Institute is being watched with ever increasing interest by those engaged in the industries which it serves. The Annual Tasting Day, for instance, has attracted for many years in succession a larger attendance on each occasion. That at the 1929 function was probably not less than 1,500 and its most encouraging feature was the type of visitor. While thoroughly representative of all aspects of the cider industry, it was mainly composed of farmers showing a keen interest in cider fruit production in farm orchards, and in cider making under farm conditions. There was also a larger attendance than usual of commercial fruit growers and market gardeners, for whom a special item of interest was provided on this occasion by the demonstration of different types of tractors and other machines and implements adapted for the cultivation of land under horticultural crops. This formed one of the series of demonstrations of this kind organised in different parts of this country during the season by the Ministry of Agriculture and Fisheries.

At other times during the course of the year the Institute was visited by parties representing or organised by the following bodies, to whom different aspects of the work in progress was demonstrated by members of the Staff.

Ministry of Agriculture and Fisheries' Insecticides and Fungicides Committee.
Ministry of Agriculture and Fisheries' Inspectors.
Reading University Horticultural Students.
Bristol Schoolmasters' Association.
Nailsworth Branch of the National Farmers' Union.
St. Paul's Junior Co-operative Guild Rambling and Nature Group.
Clifton College Scientific Club.
Brislington and District Gardeners' Association.
Luckwell Allotments, Ltd.
St. George Secondary School.
Second Imperial Mycological Conference.
British Mycological Society.
Kingswood Boys' School, Bath—Botany Class.
Gloucestershire and Somerset County Councils—Cider parties.

This list could have been extended, but it has been found necessary in the interest of the work itself to place a limit on the number of such parties, and to restrict them to those directly concerned with some feature of the work of the Institute. A similar problem exists with regard to individual visitors. Their number has become so large that it is out of the question to provide personal attention to all. Intending visitors are, therefore, requested to give a few days notice of their proposed visit, as far as possible, and to endeavour to arrange a definite appointment.

The advisory report which follows provides further information of the contacts established by the various sections of the Department with agriculturists and horticulturists during the year. As usual, exhibits at shows and exhibitions have been found valuable in that connection. A list of these occasions at which the Department was represented in this way by one or more sections is appended.

Bath and West Show, Swindon.
Devon County Show, South Molton.
Three Counties Show, Gloucester.
Imperial Fruit Show, Birmingham.
Royal Counties Show, Southampton.
Blackwood Show, Monmouth.
Abervagenny Horse Show, Abervagenny.
Melplash Agricultural Show, Bridport.
Brewers' Exhibition, London.
Bulb Show, Plymouth.
Third Annual Canners' Convention, Cambridge.
Campden Flower Show, Campden.
Worcestershire F. W. I. Exhibition, Worcester.
Derbyshire F. W. I. Produce Exhibition, Derby.
Warwickshire County Fedn. Exhibition, Warwick.
National Canners' Conference, London.

The Cider Competition Scheme of the Station has been continued with gratifying success and is reported on fully in the course of this Report. The judges for 1929 were Messrs. W. D. McCreath, S. Weston, and J. H. Wootton. The warmest thanks of the Institute are due to these gentlemen for their services in a very arduous task.

Previous Annual Reports have contained references to joint work with other institutions. That work is still proceeding and has been extended by co-operation with Dr. S. S. Zilva, of the Lister Institute of Preventive Medicine, in his investigations on the vitamins of apples and cider.

In conclusion, mention must be made of the services rendered by the non-academic members of the Staff. A large share of the work of the Department is borne by them, and what measure of success has been achieved has been in no small degree the result of their efforts.

PROGRESS REPORT ON FRUIT BREEDING.

By G. T. Spinks.

During the past year the work in connection with fruit breeding at Long Ashton has consisted chiefly in the observation of seedlings which have been raised in previous years. An increasing number of the seedling top-fruits are now coming into bearing and descriptions of these have been made, while individuals of probable utility have been selected for propagation. The various bush-fruits have also undergone observation and selection, while trials on a larger scale of previous selections have been continued.

As the result of pollination carried out in the earlier part of the year a further supply of seed of apples, plums, raspberries and blackcurrants has been obtained.

A more detailed account of the work on the various fruits is given under separate headings below.

Apples.—This year fruit was obtained from about 600 individual seedlings, of which a large number were cropping for the first time. Many of the earlier batches of seedlings raised at this Station were obtained from open-pollinated seed, and the majority of these have now fruited. A large proportion of them were useless and have now been discarded, but several have produced fruit which is good enough to warrant the propagation of the varieties for more extensive trial. The more recently raised seedlings, which are the result of controlled pollinations, are now fruiting in increasing numbers and are of much greater interest. As these seedlings are the product of crosses made with the object of combining the different good qualities of the parents it is hoped that they will include a larger proportion of good varieties than that occurring among the open-pollinated seedlings. In any case these families of crosses should yield genetical information which will be useful when making further crosses. Descriptions of the seedlings of certain families are now accumulating and before long there should be sufficient available to give some indication of the genetics of a few characters.

Trees of 7 previously selected seedlings, worked on stocks, have now been planted out for trial, while 3 other varieties have already been worked in the nursery. All these are dessert varieties, their season ranging from August to February. Two more very promising

dessert varieties, in addition to several of more doubtful value, have been selected this year for propagation. There is perhaps no great need for any new culinary varieties, but several seedlings have produced fruit of such good cooking quality that it has been thought desirable to propagate them for further trial.

Nearly 400 seedling varieties were discarded at the end of the year as of no further value.

For purposes of seed production during the year, pollinations were mainly confined to seedlings selected for some particular character, the only exceptions being some crosses of Mackintosh Red with seedling varieties. In brief, the pollinations performed were as follows :—

(1) Mackintosh Red x seedlings of good flavour and late season.

(2) Seedlings of good flavour and late season, selfed.

(3) Seedlings with certain excellent qualities, including colour, but very sweet and lacking in acidity—selfed.

(4) Seedling with excellent qualities, very early and highly coloured, but very acid—selfed.

(5) Seedlings (3) x seedling (4).

The number of seeds obtained from the self-pollinations was very small, as was also the case in previous years, and it now appears certain that many of the seedlings are so largely self-sterile that, in order to make further progress in breeding, inter-crossing rather than self-pollination must be employed.

Pears.—About 50 seedlings bore fruit this year, 20 of them cropping for the first time. Observations of the fruit and trees resulted in 17 of the varieties being discarded. One fresh variety has been selected for trial, while four selected in the previous year have been propagated, and trees of the seedling selected two years ago have been planted out for trial.

Plums.—This year 75 seedling trees bore fruit, a number of them for the first time. It is notable that a large proportion of these plums appear to be worthy of a further trial. In all, 22 seedlings have been selected, of which 4 have now been planted out as worked trees, 12 have been propagated in the nursery and 6 will be propagated in the coming season. The majority are dessert plums of good quality, several being quite first class, and the range covers the whole plum season ; several varieties of excellent dessert quality and very late in season may be useful. Up to the present, however, a number of the selections have borne only poor crops

and it is possible that an extensive trial may show them to be such shy bearers that they are of little commercial value. Several of the selected varieties bear heavy crops of good cooking plums, and if the trees prove to be resistant to various diseases they may be of value.

The following pollinations were carried out in order to obtain a further supply of seed :—

Pershore	x	Early Prolific.
,,	x	Monarch.
Purple Egg	x	Jefferson.
Blaisdon	x	Czar.
Several selected seedlings selfed.		

The pollinations, with one exception, were moderately successful and resulted in a fair number of seeds being obtained.

Black Currants.—Owing to severe spring frosts there was a poor crop in the plot of selected black currant seedlings, but the observations of the two previous years were confirmed and four of these seedling varieties will receive a further trial. These and other selected seedlings which have not yet had an extensive trial are included in a plantation which was established at the beginning of the year. The plantation contains about 3,500 bushes, the number of bushes of each variety being usually 72, divided into three units distributed in different parts of the field. Units of Baldwin and Boskoop bushes are also included in the plot to act as controls. Owing to the very dry season which followed planting, the growth on all the bushes is rather poor ; consequently fairly hard pruning is necessary and only small crops can be expected in 1930.

Seed for a second generation of plants has been obtained from a few of the seedlings. Four seedlings selected for their heavy crops and the earliness of the fruit were self-pollinated, while two were also inter-crossed. Several hundred young plants have been obtained from this seed.

Raspberries.—Trials of the three selected varieties are still proceeding. The whole of the plants of one variety were utilised a year ago for the planting of six units in the commercial variety trial, and therefore no crop was obtained from that variety this year.

The later batch of seedlings to which reference was made in the last Report were all badly affected by the severe frosts, with the result that the crops were so poor as to be useless for the purpose of selection. It is hoped that it will be possible to make selections in the coming season.

Several hundred very vigorous plants have been grown from the seed obtained in 1928 by inter-crosses between Lloyd George, Improved Beehive and an early ripening seedling. These have now been planted out for trial.

Blackberries and other Rubi.—The selected seedling blackberries have cropped well this year. There are several clones which are almost indistinguishable, but the canes of one clone were badly injured by the severe frosts of last winter and this clone has accordingly been discarded. The remaining clones escaped injury and produced heavy crops of large, early fruit of good quality and appearance. Observation of these promising varieties is being continued.

A large number of seedlings of rather complicated origin have been under observation. Originally a cross was made between the Hailsham raspberry and the Himalaya blackberry, and two F_2 plants were raised. From these two a number of plants were obtained from self-pollinated seed and also from open-pollinated seed. The majority of these plants bore very poor fruit and were discarded, but two plants bore fruit which was intermediate in character between the raspberry and blackberry, but was not quite good enough to be of practical value. These two seedlings, however, were used as parents for producing further seed by self-pollination, and by crossing with a raspberry, blackberry and loganberry, and it is these last families of seedlings which are now being considered.

It has been found that most of the plants are very vigorous, but the fertility of the flowers is so low that all the berries are poor and consist of a very small number of drupelets. None of the berries are particularly good in flavour and it is clear that all these plants are useless to the fruit-grower ; accordingly the majority of them have been discarded. A few of the superior sorts, however, have been kept, as it is possible that they may have some value as parents for raising further seedlings.

Strawberries.—The families of seedlings which had been raised with the object of producing vigorous varieties resistant to the attacks of aphis carried crops this year. On the whole the plants were very vigorous and healthy and withstood the drought very well. Large numbers of plants bore heavy crops of fruit of good quality, though none of the fruit was very early in season. The latter point is what would be expected in view of the parentage of the seedlings.

There was no difficulty in selecting a large number of plants which, as far as could be judged from single specimens, were worth

propagating for trial. The difficulty, in fact, was to restrict the number selected to manageable proportions. The numbers selected from the various families were as follows :—

Tardive de Leopold	x	Royal Sovereign	.. 13	(450)
Tardive de Leopold	x	Stirling Castle ..	.. 37	(600)
Royal Sovereign	x	Dumbarton Castle	.. 2	(180)
Royal Sovereign	x	Sturton Cross ..	.. 7	(250)
Stirling Castle	x	Sturton Cross ..	.. 2	(75)

The numbers in brackets indicate the total numbers of plants from which the selections were made.

The remaining families produced no plants worthy of propagation.

It is, of course, probable that many of the selected seedlings will not fulfil their first promise and will have to be discarded after a short trial.

Observations made last year on the incidence of aphis damage and mildew have been confirmed.

A more detailed account of the above families of seedlings appears in another part of this Report.

An extension of the work of breeding more vigorous strawberries was made this year by making further crosses, and in this case one of the aphis-resistant varieties used as a parent was Madame Lefebvre, which is an early variety. An effort was also made to introduce the desirable qualities of Paxton into some of the seedlings. The crosses made were as follows :—

Madame Lefebvre	x	Little Scarlet.
Royal Sovereign	x	Madame Lefebvre.
Sir J. Paxton	x	„ „
Stirling Castle	x	„ „
Tardive de Leopold	x	„ „
Tardive de Leopold	x	Sir J. Paxton.
Aberdeen Standard	x	„ „

About 1,600 young plants have now been raised from the seed obtained from these crosses.

FAMILIES OF STRAWBERRY SEEDLINGS BRED FOR RESISTANCE TO APHIS.

By G. T. Spinks.

In previous issues of this Report * attention has been called to the consistent vigour and health of certain varieties of strawberries, in contrast to the unhealthy state of large numbers of some of the most popular varieties such as Royal Sovereign and Stirling Castle. This vigour is apparently due largely to the resistance of the plants to the attack of the Strawberry Aphis, *Capitophorus fragariae*.

These resistant varieties, however, suffer from certain disadvantages. None of them bear fruit of first-class quality, and in most cases the fruit is late in season. There is clearly, then, a need for new varieties in which resistance to strawberry aphis is combined with good quality of fruit and, in some cases, with earliness.

Production of Seedlings.

With the object of producing such new varieties, self- and cross-pollinations were performed in 1927 and 1929. The seedlings resulting from the former year's work alone are dealt with in the present account.

Each of the resistant varieties, Aberdeen Standard, Dumbarton Castle, Sturton Cross and Tardive de Leopold, was crossed with Royal Sovereign and Stirling Castle. The first three varieties were also self-pollinated, but this was impossible in the case of Tardive de Leopold, as the flowers of that variety produce no stamens. The pollinations all resulted in the production of fruit and seeds, though in one or two cases the number of seeds was small.

The seeds were sown in boxes in the greenhouse in August, and germinated very quickly. The young plants were pricked off into boxes or small pots as soon as they were large enough, and planted out in the open during the following May. The numbers of plants obtained in each family are given below in the detailed account of the families.

* "Strawberry Investigations" (Progress Report) Agr. and Hort. Res. Stn., Long Ashton, Ann. Rept., 1927.

L. N. Staniland. "A Survey of Strawberry Plantations in England (1926-28)." Agr. and Hort. Res. Stn., Long Ashton, Ann. Rept., 1928.

The area of suitable land available for planting being very limited, it was necessary to plant very closely, and the plants were placed 12 inches apart in rows which were 18 inches apart. During the remainder of the growing season most of the plants made good growth, and any blossoms which formed were removed, with the result that very vigorous plants were obtained.

Observation and Selection of Seedlings.

Many plants were severely attacked by mildew in 1928, no attempt being made to control this disease, and at the end of the summer a record was made of the individuals which had been attacked. In the autumn, plants which showed symptoms of aphis damage were also marked down. It was found that aphis was present on practically all the plants, but in the majority of cases it appeared to cause no damage. The marked plants, however, showed the characteristic symptoms of aphis damage.

In the spring of 1929, the bed of seedlings, as a whole, appeared very healthy and vigorous. Blossom was abundant and only slight injury was caused by the severe late frosts which occurred: this was doubtless due to the comparatively late blossoming season of most of the plants. The time of blossoming of each individual plant was noted, also the type of blossom, whether perfect or consisting of pistillate flowers only.

The two largest families of seedlings bore heavy crops of fruit, which, on the average, was of very good quality. In fact, this portion of the bed, consisting of individual seedlings, compared very favourably with any bed of plants of a single standard variety. Notes were made on the fruit of as many plants as possible, but it was found impracticable to note every plant. Descriptions were therefore limited to the plants which bore the heaviest crops or the largest fruit. All the plants withstood the severe drought of the summer very well.

The most promising plants were marked for propagation and further trial, and, in all, 61 plants were selected for that purpose. Runners from the selected plants were planted out in August and are now well established. The young plants will provide a further supply of runners in 1930, but will be prevented from fruiting in order to avoid weakening the runners.

During the summer the seedling plants suffering from mildew were again noted, the attack being classified arbitrarily as bad, moderate and slight or none. Notes were also made on the occurrence of plants affected by aphis. It was found that the plants

marked down in the previous year were still more seriously affected and a number of fresh cases of injury were noted. In some families, however, there was still only a very small number of plants which were affected.

It was impossible, owing to the large number of plants involved, to make any botanical description, or even any general description of habit, of the individual plants ; but a few particular cases were noted where the foliage showed some outstanding character.

As the plants were too crowded for optimum development and for the purpose of effective observation, roughly one half were removed during the winter 1929-30. Plants selected for propagation, and others noted as fairly good have been retained, but, as far as possible, alternate plants have been removed, in addition to aphis-affected plants. The remaining plants will again be observed, mainly with the object of confirming previous selections and of making further selections if the second year of cropping reveals any additional plants of merit.

The following account presents a summary of the chief points noted in the seedlings of the various families :—

Notes on the Families.

Tardive de Leopold × *Royal Sovereign.* (446 plants.)

The plants in this family were mainly vigorous and very leafy, the leaves being large. In colour the leaves resembled those of Royal Sovereign and they also frequently showed the same corrugated surface, though in some cases the surface was more even. Many plants resembled Royal Sovereign closely, but usually had a larger number of leaves ; others more nearly resembled the other parent and there were many intermediate types. In many cases the flower trusses and leaves were distinctly erect in habit, but it is possible that the crowded state of the plants was partially reposible for this.

As regards vigour, 25 plants were classed as weak, 30 as moderate, and the rest as vigorous. The family as a whole was, therefore, very vigorous.

The amount of mildew present could only be judged by rough arbitrary standards, but was noted as very bad on 13 plants, bad on 99, slight or absent on only 13, while on the rest of the plants it was moderate. This family therefore showed a fairly high susceptibility to mildew.

Of the whole family only 15 plants were found to be affected by aphis, the rest being very resistant to this pest. Red spider was found to have damaged 8 plants.

Blossom was distinctly inclined to be late. Only 15 plants were classed as blossoming earlier than at a medium time, and none were really early. On the other hand the blossom of 60 plants was classed as late, and of 11 as very late, while that of about 300 plants was noted as medium or moderately late. On 68 plants no flowers were borne, though most of these plants were vigorous and healthy ; it is possible that some of these will flower in 1930.

In view of the parentage of this family it was interesting to note the numbers of seedlings which bore perfect and unisexual flowers. It was found that the types were present in almost equal numbers, viz. 182 plants with perfect flowers and 199 with flowers which were pistillate only. No case was observed of a plant bearing both types of flowers.

Notes on the fruit were taken on only 93 plants, but these may be taken as representative of the whole family except as regards crop and size of fruit, and in these respects they were superior to the average plant.

In describing the fruit no attempt was made to work to any exact standards and the various points were judged by eye, touch or taste, as the case might be. The data therefore cannot be directly compared with those obtained at other times and places, but they probably indicate fairly well the relative differences found in the present investigation, as all the notes were made by the same observer.

The fruit of this family of seedlings was almost entirely mid-season in time of ripening. Only a very few plants bore fruit which was either early or late in season.

The standard for amount of crop was probably set fairly high and 16 plants were classed as carrying really good crops, 47 as fairly good and most of the rest as moderate. The proportion of plants with poor crops was small.

The size of the fruit was noted as large on 55 plants, and moderately large on 27. On the majority of the remainder the fruit was of moderate size, few plants carrying really small fruit.

In colour the fruit tended to be bright scarlet. On about one-third of the plants the fruit was described as scarlet, and on a rather larger number as intermediate between scarlet and crimson. On the rest the colour was either a darker crimson or a distinctly pale shade of scarlet or crimson. Fruits with red flesh were of fairly frequent occurrence.

About two-thirds of the fruits were described as conical in shape, the remainder being wedge-shaped, oval, round, or irregular in approximately equal numbers. Many intermediate shapes occurred and the above classification is only approximate. Frequently the fruits on one individual plant vary considerably in shape.

The texture of the fruit, as judged by pressure with the fingers, was classified as firm, medium and soft. On the 93 plants described the fruit was found to be almost equally divided between the three classes.

As regards flavour, the fruit of 5 plants was described as good, of 16 as fairly good, 49 moderate and 16 poor.

Taking into account the various characters of the plants and fruit, and the fact that all the desirable characters are rarely found combined, it was decided that 13 plants from this family were good enough for propagation and further trial. Of these 8 bear only pistillate flowers, which is a point against them. Other things being equal, a plant with perfect blossoms is much to be preferred to one with pistillate flowers, but, as it is possible that a plant may be sufficiently good in other respects to counterbalance the disadvantage of the imperfect flowers, these 8 varieties will be given a trial. Unless, however, they prove to have some markedly superior qualities they will be discarded in favour of varieties with perfect flowers.

Tardive de Leopold × *Stirling Castle.* (579 plants.)

The plants in this family were very vigorous and leafy. On the great majority the leaves were rather bright green in colour and the leaflets were fairly flat with an even surface, free from pronounced corrugations. A small number of plants, however, were decidedly dark in colour. Flower trusses and leaves, as in the previous family, were often erect.

The majority of the plants were distinctly vigorous, only 28 being classed as moderate and 13 as weak, while 18 were noted as being particularly vigorous.

In contrast to the previous family, the plants of this were very free from mildew, only 48 plants showing any noticeable amount. About 12 plants were rather badly attacked.

This family has been very resistant to the attacks of aphis, only 2 plants showing aphis damage having been found.

The blossom was rather earlier than in the last family. Rather less than a quarter of the plants were early or moderately early in

blooming, slightly more were late or moderately late, while on half the plants the blossom was medium in season. The numbers of really early and late-blossoming plants were quite small.

Observation of the flowers showed that in this family also the pistillate type was slightly more common than the perfect flower, the numbers being 298 and 267. On 14 plants no flowers were borne.

The season of the fruit of this family was almost the same as that of the previous family, though possibly two or three days later. The fruit of only 12 plants was described as early, and of 7 as late. All the rest of the plants ripened their first fruits within the same period of four days in the middle of the season.

The plants of this family gave the general impression of being good croppers. The crop was noted as being good on 29 plants and fairly good on 125, while most of the remaining plants, on which no notes were made, would probably be classed as moderate croppers. The number of plants carrying poor crops was not large.

Fruit size was noted as large on 45 plants and moderately large on 77.

The colour of the fruit was, in general, fairly bright. Of the fruits noted, 54 were described as scarlet, 19 as crimson and 78 as intermediate between those two colours, while 20 were of a distinctly pale shade. Colour of flesh was largely overlooked in examining the fruit, but a few fruits were noted as having red flesh.

Most of the fruit tended towards a conical shape, round fruit being considerably less common, while other shapes occurred in still smaller numbers. Fruits intermediate in shape were found in many cases.

The texture of much of the fruit was inclined to be soft. Notes were made on 183 plants, and of these the fruit was described as firm, moderate and soft in 35, 63 and 85 cases respectively.

Notes on flavour were made in only 57 cases, as flavour was not usually tested unless a plant showed a combination of most of the other desirable qualities. The flavour of the fruit on 4 plants was classed as good, on 24 as fairly good, on 25 as moderate and on 4 as poor. It is not, of course, possible to say whether the same proportions of the various classes of flavour would be found in the rest of the cases which were not tested.

This family yielded a large number of plants which were thought worthy of a more extended trial, and 37 have been propagated, 19 of these having pistillate flowers.

Royal Sovereign × *Aberdeen Standard.* (114 plants.)

In habit and general appearance the plants exhibited various gradations between the two parents, but on the whole they more nearly resembled Royal Sovereign.

Blossom was medium to late in time of opening, there being no early blossoms and only 8 moderately early. No pistillate flowers were found in this family or in any of those described below.

The plants were of moderate vigour and only two vigorous plants were noted, while 12 were weak.

Mildew was serious on many plants, being moderately bad on 68 and very bad on 20. Badly mildewed berries were common.

Only two plants were found to be damaged by aphis.

No heavy-cropping plants were noticed and the fruit was rarely large or particularly attractive in appearance, consequently but few notes on the fruit were made. The mediocre crop and quality may have been due largely to the severe attack of mildew.

No plants were considered to be worth propagating.

Royal Sovereign × *Dumbarton Castle.* (180 plants.)

The plants of this family were mainly moderately vigorous, only 11 plants being classed as weak and 5 as very vigorous.

Mildew was bad on 19 plants, moderate on 88 and slight or absent on 73.

Plants damaged by aphis numbered 6 and red spider injury was noted on 6 plants.

Blossom was late or moderately late in the majority of cases and no early blossom was noted.

The fruit of this family was, on the whole, not very good, with the result that few notes were made. The fruit was mainly mid-season, though 4 moderately early plants and a number of late ones were noted. Only 3 plants were noted as being definitely heavy croppers, and in only 3 cases was the fruit classed as large.

The fruit was mainly scarlet in colour and conical in shape, though there were variations.

No general statement can be made concerning texture or flavour.

Two plants only were selected for trial.

Royal Sovereign × *Sturton Cross.* (255 plants.)

This family consisted of 173 plants which were fairly vigorous, 38 rather weaker, and 44 distinctly weak.

Mildew was bad on 15 plants, moderately severe on 117 and either slight or absent on the remaining number.

Aphis damage was found on 38 plants and red spider injury on 7, which accounts for the number of weak plants noted above.

Blossoming times ranged from early to very late, with the majority of plants in an intermediate position. 29 plants produced no flowers and though a few of these had been weakened by aphis the majority were healthy and vigorous plants.

Most of the fruit of this family was unattractive in shape and colour, while the flavour was also poor. Very few notes were made on the fruit of individual plants.

The fruit ripened mainly in mid-season, but a number of rather later plants were noted, and these will be observed again in 1930. The crop, as a whole, was moderate, but good crops, usually of large fruit, were noted on 13 plants.

A selection of 5 plants was made for further trials.

Stirling Castle × *Dumbarton Castle.* (95 plants.)

The plants of this family were about equally distributed among the classes weak, moderate and vigorous.

Mildew was not serious on most of the plants, only 12 seedlings being recorded as badly or moderately attacked.

Aphis, on the other hand, was found to have damaged 51 plants, while red spider injury was found on 11 plants. In some cases the same plant was attacked by both pests.

Blossoming time in most cases was medium or moderately late.

Rather poor crops were the rule and no notes were made on the fruit. No plants were selected for propagation, though 10 plants bearing fairly late fruit were marked for further observation.

Stirling Castle × *Sturton Cross.* (78 plants.)

This family again consisted chiefly of rather inferior plants, only about 28 being fairly vigorous, while 27 were distinctly weak.

Mildew was bad on only one plant, and moderate on 20, the rest being almost free from the disease.

Plants affected by aphis numbered 34, and red spider had seriously injured 19.

Nearly all the blossom opened at a medium season. About 10 plants, the fruit of which varied in season from early to late, were marked for observation in 1930, but only 2, both of which bore good crops, have been propagated.

Stirling Castle × *Aberdeen Standard.* (61 plants.)

Only about 10 plants of this family were vigorous in growth, the remainder being weak or moderate.

Mildew was moderately serious on half the plants, while the rest were only slightly attacked.

Aphis caused much damage, 40 plants being attacked.

Fruit varied from early to late in season, but none of the plants bore good crops or fruits of large size. No plants were considered to be worth propagating.

Dumbarton Castle selfed. (98 plants.)

Only 7 plants of this family were even moderate in vigour, the rest being weak. About 25 plants were definitely affected by aphis, but it was not possible to determine how far the weakness of the remainder was due to aphis. It is possible that they had been affected when very young, but the weakness may have been inherent in the seedlings, possibly owing to the seedlings having been obtained by selfing.

There was practically no crop and none of the plants have been propagated.

Sturton Cross selfed. (78 plants.)

This family also consisted almost entirely of weak plants, only 8 being vigorous or moderate. On 29 plants there was a moderate attack of mildew. The number injured by aphis was again uncertain, though about 40 seemed to have been affected.

The crop was negligible and no plants were propagated.

As the last two families were both planted on one side of the plot, it is possible that the weakness of the plants was due to some factor external to the plants. No difference in the soil could be detected, however, and, as far as could be traced, the previous treatment of the ground and the treatment of the strawberry seedlings had been identical over the whole plot. It therefore appears probable that the weakness was due to qualities inherent in these two families, including a susceptibility to aphis attack. This view is supported by the occurrence of a few vigorous plants among the weak ones.

Aberdeen Standard selfed. (5 plants.)

This very small family contained 3 vigorous plants, the other 2 being only moderate. It was noticed that the foliage of 4 plants

was dark in colour, resembling that of the parent, while the leaves on the remaining plant were of a brighter colour. All the plants were free from mildew and aphis. The crop was poor and no plants were propagated.

The writer wishes to acknowledge the assistance given by Mr. L. N. Staniland, who marked down the plants which were affected by aphis and red spider.

Summary.

1. Several families of seedlings have been obtained by crossing or selfing varieties of strawberries resistant to aphis; the plants and fruit have been observed and a number of promising plants have been propagated for further trial.

2. In the family *Tardive de Leopold* × *Royal Sovereign* almost all the plants were vigorous and resistant to aphis, but rather highly susceptible to mildew. About half the plants bore flowers which were pistillate only. The average crop and quality of fruit were fairly good and 13 plants have been propagated.

In the family *Tardive de Leopold* × *Stirling Castle*, the plants were very vigorous and resistant to aphis, the great majority of them also being resistant to mildew. About half the plants bore pistillate flowers. The average crop and quality of fruit were good and 37 plants have been propagated.

The families *Royal Sovereign* × *Dumbarton Castle* and *Royal Sovereign* × *Sturton Cross* were less vigorous and were fairly susceptible to mildew. The former was resistant to aphis, but the latter was rather susceptible and bore fruit of poor quality. A few plants were selected from each family.

In the family *Royal Sovereign* × *Aberdeen standard* the plants were of moderate vigour and often very susceptible to mildew, though resistant to aphis.

The families *Stirling Castle* × *Sturton Cross* and *Stirling Castle* × *Aberdeen Standard* were moderately vigorous or weak, only moderately susceptible to mildew, but susceptible to aphis.

Dumbarton Castle and Sturton Cross, when selfed, produced families of weak plants very susceptible to aphis.

3. In the families considered the following hereditary effects can be traced :—

Tardive de Leopold produced seedlings almost all of which are resistant to aphis ; about 50% of the seedlings bear pistillate flowers.

Royal Sovereign transmitted to seedlings a considerable susceptibility to mildew.

Stirling Castle produced in seedlings a considerable resistance to mildew but a susceptibility to aphis except in the family *Tardive de Leopold* × *Stirling Castle*.

SELF-FERTILITY AND SELF-STERILITY IN CIDER VARIETIES OF APPLES.

By G. T. Spinks.

Introduction.

It has been established by the experiments of a number of workers that many varieties of apples are either partially or completely self-sterile, *i.e.* no fruits or very few fruits, develop when the blossom is pollinated with its own pollen or with pollen from another flower of the same variety. This fact has important practical results, for it means that a large block of trees of a single self-sterile variety will set very little fruit. In order to ensure a satisfactory crop on such a variety it is necessary to interplant with trees of another variety which is in bloom at approximately the same time. The self-sterile blossoms will then receive pollen, through the agency of bees and other insects, from the second variety and a much better set of fruit will be obtained.

Lists of self-sterile varieties of apples have been published by Chittenden (1), Rawes (2), Crane (3, 4), Hooper (5, 6) and other workers in England, and these are of great assistance to a fruit-grower when planning new plantations, as they enable him to select a suitable mixture of varieties for his plantation, so that each variety will be effectively pollinated. Workers in other countries have carried out similar experiments on the self-sterility of the varieties grown in those countries.

All the above work, however, has been done with dessert and culinary varieties of apples, and no information concerning the self-sterility of recognised cider varieties of apples has been published. Orchards of cider apples commonly contain a large number of different varieties, but in recent years growers have been advised to reduce the number of varieties grown, and to concentrate on a few varieties which have been found to produce the best cider either when used singly or when blended. Anyone laying out a new orchard of cider apple trees at the present time will probably wish to plant a considerable number of trees of one variety, and in order to avoid any possible bad effects from planting too many in one block it will be of advantage to know to what extent the variety is self-sterile. Accordingly, during the last four years, pollination

trials have been carried out at Long Ashton to obtain information regarding the self-sterility or self-fertility of some of the recommended cider varieties of apples, and the following is an account of these trials and the results which have been obtained up to date.

Method of Procedure.

The conditions under which the trials were carried out were anything but ideal from the experimental point of view if the object had been to give every flower pollinated the best possible chance of setting, and negative results must perhaps be viewed with even more caution than usual. On the other hand, as the conditions were similar to those occurring normally in most cider orchards, the positive results are a good indication of the set of fruit which will be obtained under ordinary commercial conditions.

The trials were carried out in the cider orchard at the Research Station, on large standard trees which were between 20 and 25 years old. Most of the trees were vigorous and in a healthy state, though in a few cases, notably Kingston Black, the blossom was very weak owing to the whole tree being unhealthy and cankered. Pests were not always completely controlled, and aphis in particular was somewhat troublesome and damaged the flowers and young fruit.

The blossoms which were self-pollinated were protected by waterproof paper bags, but otherwise they were subjected to the weather conditions which happened to prevail at the time of the experiment. Only in one or two cases, however, was it thought that the conditions were definitely unfavourable for successful pollination.

The method of carrying out the trials was as follows :—On each variety of tree, blossom trusses were covered with the paper bags when the most advanced flower of each truss was almost ready to expand its petals, the neck of the bag being tied with string round the stem of the truss so as to prevent the entrance of insects. Usually 20 trusses on each variety were bagged in this way. At the same time, an equal number of trusses in a similar stage of development were marked with labels, but were not bagged. A few days later, when it was found that the stamens were shedding their pollen, each flower of the bagged trusses was pollinated by lightly touching the anthers and stigma with the fingers, the bags then being replaced. Precautions against cross-pollination were taken by sterilising the fingers with alcohol before starting to pollinate a fresh variety. The unbagged trusses were not touched, but were left for pollination to be effected naturally by insects. When the flowers had passed the stage at which pollination could take place

the bags were removed from the self-pollinated trusses. During June a count was made of the number of fruits which had set on each bagged and marked truss.

No count was made of the number of fruits which eventually matured, and this would probably have been less than the number counted in June, but all the fruits noted had apparently been effectively fertilised, and any further dropping which took place would be due to lack of sufficient food-supplies to enable all the fruits to mature.

Similar pollinations and counts were carried out on most of the varieties in four successive seasons, and the results are given in Table I. below. The number of flowers used in each test was not always the same, though it was usually 100-120, but for greater ease of comparison, the number of fruits set in each case has been expressed as a percentage of the number of blossoms pollinated.

TABLE I.

Percentage of Flowers Set.

	1926.		1927.		1928.		1929.	
	S.	O.	S.	O.	S.	O.	S.	O.
Cap of Liberty	0	0	—	—	5	51	0	23
Cherry Norman	—	—	0	32	—	—	0	53
Chisel Jersey	0	1	16	43	5	38	3	39
Court Royal	1	2	1	7	3	17	—	—
Dabinett	2	6	14	39	9	38	15	47
Dymock Red	6	7	4	5	0	2	21	0
Eggleton Styre	0	0	0	5	0	11	0	4
Foxwhelp	—	—	—	—	—	—	0	6
Kingston Black	3	7	0	12	—	—	—	—
Knotted Kernel	2	3	1	14	16	55	0	23
Reinette Obry	18	0	20	20	9	14	11	20
Strawberry Norman	0	6	3	25	0	50	0	64
Sweet Alford	0	3	1	4	0	4	0	2
Sweet Coppin	3	8	0	21	7	23	3	41
Tom Putt	0	10	0	0	—	—	—	—
White Jersey	—	—	1	42	0	34	9	43

S = self-pollinated.
O = open-pollinated.

CONSIDERATION OF DATA AND CONCLUSIONS.

In considering the above figures, the following points should be noted :—

In 1926, most of the trees were rather badly infested with aphis, apple sucker and woolly aphis, as they had not received any winter spray. This will account for many of the low figures in that year.

In 1927, the blossom used on Kingston Black and Eggleton Styre was poor, as pollination was left too late and only late weak blossom was available.

In 1928, it was noted that the pollen was very good on Sweet Alford, Chisel Jersey, Knotted Kernel and Court Royal, while the weather was very damp and cold when White Jersey was pollinated.

In 1929, the blossom of Cherry Norman was poor and no pollen could be detected.

From an examination of the figures in the table the following deductions can be drawn :—

(1) Many of the varieties set a large percentage of their blossoms when open-pollinated, notably Cap of Liberty, Cherry Norman, Chisel Jersey, Dabinett, Knotted Kernel, Strawberry Norman, Sweet Coppin and White Jersey. The set obtained on Reinette Obry was not so large, but would probably produce a full crop.

(2) Almost every variety gave a considerably better set when open-pollinated than when self-pollinated. The differences may be exaggerated by the conditions under which the self-pollination was performed.

(3) The varieties Dabinett and Reinette Obry consistently show a fairly high degree of self-fertility, while Chisel Jersey, Dymock Red, and Knotted Kernel only once gave a good set when self-pollinated.

(4) Cap of Liberty, Court Royal, Sweet Coppin and White Jersey appear to be only slightly self-fertile.

(5) Cherry Norman, Eggleton Styre, Sweet Alford and Strawberry Norman seem to be almost entirely self-sterile.

(6) The figures available for Foxwhelp, Kingston Black and Tom Putt are not sufficient to allow any conclusions to be drawn.

Time of Blossoming.

The question of suitable varieties for pollinating the self-sterile varieties may now be raised. Although no actual trials were made, one may perhaps assume, judging from the facts known about other varieties of apple, that any variety can be successfully pollinated by any other variety if the blossoming periods overlap sufficiently.

The dates of the entire blossoming periods of the varieties used in this trial were not observed, though the actual dates of pollinations were noted. The dates were naturally different in the different years, and in some years the season of bloom was more extended

than in others, but an average order of blossoming can be found. Moreover, in a former Long Ashton Report (7) the blossoming dates of most of these varieties over a period of six years are given. From these two sets of observations the following average order of blossoming has been worked out :—

Early	Eggleton Styre. Court Royal. Cap of Liberty. Knotted Kernel.
Moderately Early	Chisel Jersey. Dymock Red. Foxwhelp. Reinette Obry. Kingston Black.
Moderately Late ..	Dabinett. Sweet Alford.
Late	White Jersey. Cherry Norman. Strawberry Norman.

The best trees for supplying pollen to any one of the above varieties will probably be those of other varieties which are placed in the same group, *e.g.* satisfactory pollination of Court Royal should be obtained if trees of Eggleton Styre, Cap of Liberty or Knotted Kernel are growing near, though varieties in the second, or even in the third, group should be of use in pollinating those of the first group. Similarly for any other variety the best pollenizers will be those which are nearest in the above list. Varieties in the first group, however, are probably of little value for pollinating those in the last group and vice versa.

It is recognised that further pollination trials, possibly carried out under conditions more favourable for self-pollination, are necessary before these cider varieties of apples can be definitely classified as self-fertile or self-sterile ; but the above data provide some indication of the degrees of self-fertility occurring under ordinary orchard conditions.

The writer wishes to acknowledge the valuable assistance given by Mr. J. E. Shaw who has carried out the greater part of the bagging, pollination and recording in this trial.

Summary.

1. Records have been taken of the set of fruit obtained on self-pollinated and open-pollinated flowers of several cider varieties of apples.

2. Open-pollination is almost always more effective than self-pollination.

3. The following provisional classification is made :—

SELF-FERTILE	Dabinett, Reinette Obry.
SLIGHTLY SELF-FERTILE ..	Cap of Liberty, Chisel Jersey, Court Royal, Dymock Red, Knotted Kernel, Sweet Coppin, White Jersey.
SELF-STERILE	Cherry Norman, Eggleton Styre, Sweet Alford, Strawberry Norman.

4. The order of blossoming is given in order to indicate suitable varieties for providing pollen for self-sterile trees.

REFERENCES.

(1) CHITTENDEN, F. J. "Pollination in Orchards" (iii). *Journal of Royal Hort. Soc., Vol. XXXIX*, p. 615 (1913-14).

(2) RAWES, A. N. "Pollination in Orchards" (v.) *Journal of Royal Hort. Soc., Vol. XLVII.*, p. 8. (1922).

(3) CRANE, M. B. "Reports on Tests of Self-Sterility and Cross-Incompatibility in Plums, Cherries and Apples." (II). *Journal of Pomology and Hort. Science, Vol. III*, p. 67. (1923).

(4) CRANE, M. B. "Studies in Relation to Sterility in Plums, Cherries, Apples and Raspberries." *Mem. of Hort. Soc. of New York.* 3 : 119-134, p. 8. (1927).

(5) HOOPER, C. H. "Fruit Pollination in Relation to Commercial Fruit Growing.' *South-Eastern Agric. Coll., Wye, Fruit Bul.* 10. (1928).

(6) HOOPER. C. H. "The Study of the Order of Flowering and Pollination of Fruit Blossoms Applied to Commercial Fruit Growing." *Journ. of the Royal Soc. of Arts. Vol. LXXVII.* (March 8, 1929).

(7) Agric. and Hort. Research Stn. Long Ashton. *Ann. Rept.*, 1913, p. 35.

THE TIME OF DIFFERENTIATION OF THE FLOWER-BUD OF THE APPLE.†

By Margaret A. Gibbs§
and
Thomas Swarbrick.

Introduction.

It is now common knowledge that the flowers of most fruit trees are formed during the summer preceding the spring in which they open. The exact time of this differentiation, the sequence and the order of floral development have been the subject of considerable study and investigation during recent years, particularly in America. E. S. Goff (5) as early as 1899 investigated the flower bud formation of the apple, plum, pear and some small fruits such as the currant and gooseberry. He recorded a common order of flower part formation, namely, sepals, petals, stamens and finally the carpels. After the flower bud initiation, development was continued slowly until leaf fall and early winter. Then followed a period of retarded development which continued throughout winter. This was in its turn followed by a vigorous development in spring, starting about March and ending in the full development of complete flowers in May.

The plum has been investigated from this standpoint by Goff (5) and Drinkard (4) in America, Luytens (6) in Holland, and Ball(1)at Long Ashton, England. These workers find that the time of differentiation varies according to the species under investigation, but that, in general, flower bud initiation takes place from mid-July to early August. Ball (1) has shown, further, that climatic conditions influence the time of the differentiation. For the cherry in America, Drinkard (4) and Goff (5) found the first flower primordia in the first two weeks of July. Luytens and De Vries (7) working on the pear in Holland, found that differentiation began in early August.

Bradford, (2) using the Yellow Newton variety of apple and working in the Pacific Northwest, found that the flower primordia appeared during the first ten days of July. Tufts and Morrow (11) give June 11th as the earliest date on which they were able to

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observe it. Goff (5) in his work on the apple found two periods of differentiation, one in July and another in September, and Magness (8) has shown that the axillary buds do not show flower bud primordia until at least a month later than do spur buds. Bijhouer (3) in Holland found that flower parts were initiated about the middle of June.

Ranker, (9) working on the " Delicious " apple in U.S.A., found that differentiation began in a few buds by June 19th and was general by July 2nd, and complete by August 17th. There was no second period of differentiation. All the trees from one orchard were a week behind in all the stages of flower bud formation, and this was correlated with a heavier type of soil.

It is clear, therefore, that in this matter of the time of flower-bud initiation, there is considerable variation. Climatic conditions, age of tree, rootstock, variety, cultural conditions and pruning treatment may all exert an influence. The time of flower-bud initiation is obviously a critical period in orchard management, because there can be no crop unless there is adequate blossoming. In order, therefore, to obtain the best results, it is necessary to have a reasonable idea of this time *for the locality under consideration*. It is thus a matter that should be worked out in every large fruit growing area. Workers in other countries may give us approximate times, but the present authors would argue for the desirability of this to be worked out under known conditions for each area. Clearly, in our own country in most years, there will no doubt be several weeks' difference between the time of flower bud initiation in the East and in the West of England. Further, the fruiting habit of the trees must be considered for some varieties are known to bear the major part of their crop on the tips and at axillary buds on one year old wood. Since various phases of " The Factors Governing Fruit Bud Formation " have been under investigation at Long Ashton for many years now, the present study was started in order to fix this time for our own area. Trees of the variety Lane's Prince Albert were used because they were in that condition where they were bearing on spurs and on current year's wood, so that it was possible to study the time of flower bud formation at these two tree " positions " on the same trees.

Experimental Method and Material.

The variety of apple Lane's Prince Albert of about ten years old growing upon Malling Type 2 rootstock was used in this investigation. The trees were growing under clean cultivation and were making fairly good growth. They carried a heavy crop in 1927, but only a light crop in 1928, the year when the examination was

made. Buds were collected from three similar trees so that there can be no question of disturbed growth owing to the removal of buds and leaf surface.

Three series or classes of buds were collected, five buds at each picking at weekly intervals from early June to late August and then fortnightly until November. The first series was that of spur buds from single spurs growing on three year old, *i.e.*, 1926, wood. The second series was that of spur buds from single spurs on two year old, *i.e.*, 1927, wood. The third series was of axillary buds on the current season's wood, *i.e.*, 1928, shoot growth. The collection of the first series was begun in June, the second series in July and the third series in August.

All buds were removed close to the base with a sharp knife and placed immediately into Gilson's fixative fluid, and were then removed to the laboratory where they were evacuated in the fixative from twenty-four to forty-eight hours. They were then washed and dehydrated through the 'alcohols' following the usual technique. When the buds were in 70% alcohol they were cut off from the woody base and the outer scale leaves were removed. The buds were then passed on into absolute alcohol, cleared in xylol and embedded in wax, of a melting point 50°C.

When the first block was cut no sections were obtained, the material falling to pieces. This was found to be due to a layer of air caught in the hairs between each set of bud scales. Various methods were tried to free the bud from air and the following was ultimately found to be satisfactory. The buds were taken back through xylol and the 'alcohols' to water. The tips were removed and the scales dissected off to the growing point. The buds were then evacuated in air-free distilled water, and passed up through the 'alcohols' with evacuation in each. They were cleared in chloroform, embedded in vacuo at both the paraffin stages. The sections were stained with hæmatoxylin.

The criterion of the beginning of a flower-bud initiation is that given by the workers cited earlier, namely a preliminary flattening of the apex of the growing point (see Figs. 1 and 2). This appears to be the first morphological evidence of the impending subsequent development. Clearly, as indicated by Swarbrick, (10) the determinative influence must be operative even earlier than the observed flattening of the apex of the growing point. At the present stage of our knowledge, however, we must be content with this first morphological evidence, but in determining practice we should bear in mind this probability and act accordingly.

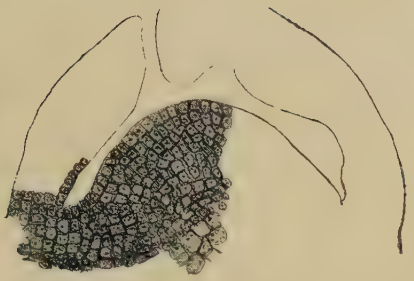

FIG. 1. First Series. June 18th, 1928.

FIG. 2. First Series. June 25th, 1928.

FIG. 3. First Series. July 2nd, 1928.

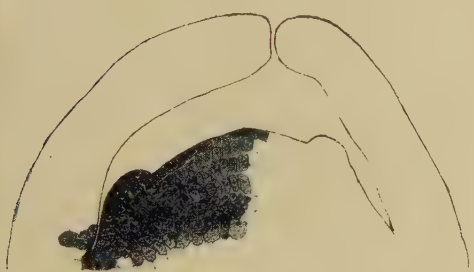

FIG. 4. Second Series. July 2nd, 1928.

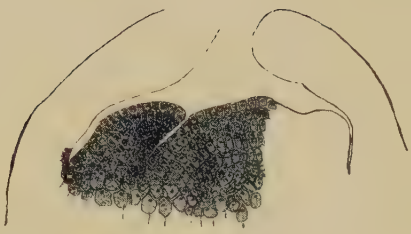

FIG. 5. Second Series. July 9th, 1928.

FIG. 6. Third Series. August 4th, 1928.

FIG. 7. First Series. August 18th, 1928.

FIG. 8. Third Series. August 18th, 1928.

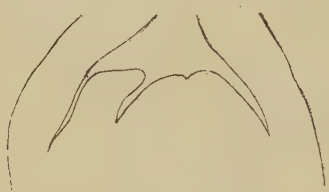

FIG. 9. Second Series. July 16th, 1928.

THE TIME OF FLOWER-BUD DIFFERENTIATION OF THE APPLE

For description of figures see text.

Results.

First Series, i.e. Spur buds from single spurs on 1926 wood.

Buds of this series collected during the first two weeks of June showed only a purely vegetative structure (see Fig. 1). Sections from a bud of this series gathered on June 25th showed the preliminary stages of flower-bud formation, namely the flattening and broadening of the growing point apex (see Fig. 2). Several buds of the next picking—July 2nd—showed distinct flower-bud primordia in the form of small projections, one on each side of the apex (see Fig. 3). These primordia continued to develop and be initiated throughout July, so that by the 18th of August the sepal primordia were well developed although at this date the petal primordia were not yet initiated (see Fig. 6).

Second Series, i.e. Spur buds from spurs on 1927 wood.

The first buds examined from the first gathering of this series on July 2nd were found to have distinct flower-bud primordia at about the same stage of development as the buds of series one gathered on the same day (see Fig. 4). Subsequent pickings in this series showed the same stages of flower-bud initiation and development was proceeding at about the same rate as in the buds of series one (see Fig. 5). The sepal primordia of this series were first seen in buds gathered on July 22nd.

Third Series, i.e. axillary buds on 1928 shoot growth.

As mentioned earlier the collection of these buds was not begun until the first week in August. At this time flower primordia were present in some of the buds gathered. By the 18th August the sepal primordia were initiated and development was proceeding rapidly.

Summary and Conclusions.

A study of the time of flower-bud differentiation in the spur and axillary buds of apple trees has been carried out at Long Ashton in the summer of 1928. In the buds of spurs on one and two year old wood, it was found that the differentiation of the flower parts begins to take place at about the same time, that is during the last fortnight in June. Sepal primordia were distinguishable in these buds on July 2nd, 1928. On the current year's wood not all the axillary buds developed into flower-buds. In those cases where blossoms were initiated, the primordia were found present in buds of the first gathering which was made on the 4th August, 1928, but at this time the primordia were in the same stage of develop-

ment as the spur buds were on July 2nd, that is over a month earlier. Thus, flower-bud differentiation when it occurred in axillary buds on current season's growth took place a month later than it did on spurs on the same trees.

The development of the flower parts on the axillary buds was more rapid than in the spur buds because by the 18th August, the buds of all three series showed sepal, but no petal primordia (see Fig. 7, *c*). By the end of the growing season there was little or no difference in the stage of development reached by the buds of all series.

It is pointed out that the year 1928 was a favourable one for flower bud formation at Long Ashton by reason of the dry summer and that this may have in some measure been responsible for the earliness of flower-bud initiation. In any case it would appear that flower-bud formation may be expected to begin at the end of June or during early July and that conditions prevailing at this time and earlier are very important in that they affect the amount and vigour of the flowers that are initiated. It is also seen that fruit thinning at a later date than this can have little effect upon the amount of flower-bud initiated that year, because the critical time has already passed.

In determining orchard practice and management, it is evident that the period May-June is very important and that conditions prevailing during the preceding autumn, such as crop, rainfall and soil conditions may give hang-over effects which it is necessary to have in mind when determining orchard management and cultural treatments in spring.

The results may be summarised as follows :—

Date.	Series I.	Series II.	Series III
6.6.28	Purely vegetative		
13.6.28	do.		
25.6.28	Apex flattened		
2.7.28	First signs of primordia	First signs of primordia	
9.7.28	Primordia developing		
22.7.28	First signs of sepals	First signs of sepals	
4.8.28	Development continued		First signs of primordia
18.8.28	Sepals differentiated		Sepal primordia

The authors are indebted to Dr. Skene of the Department of Botany, The University, Bristol, for suggesting some co-operative activity with his department and for his interest in this work.

References.

(1) Ball, E. *Journal of Pomology*, Vol. 6, pp. 198-208, 1927.
(2) Bradford, F. C. *Oregon Agric. Exp. Sta. Bulletin*, 129, 1915.
(3) Bijhouer, J. *Laboratorium voor Plantenphysiologie Wageningen*, 1924.
(4) Drinkard, A. W. *Annual Report Virginia Polytechnic Inst. Agr. Ex. Sta.* 1909-10.
(5) Goff, E. S. *Annual Rept., Wisconsin Agric. Exp. Station*, 1899-1900.
(6) Luyten, Ida. *Laboratorium voor Plantenphysiologie, Wageningen*, 1921.
(7) Luyten, I., and de Vries, E. *Laboratorium voor Plantenphysiologie, Wageningen.*
(8) Magness, J. R. *Oregon Agric. Exp. St. Bulletin*, 139, 1916.
(9) Ranker, E. R. *American Journal of Botany*, V. 13, p. 406, 1926.
(10) Swarbrick, T. *Journ. of Pomology*, Vol. VII, p. 100-129, 1928.
(11) Tufts, W. P. and Morrow, E. B. *Hilgardia*, Vol. I, pp. 3-14, 1925.

Notes on Figures.

Fig. 1. First Series, June 18th, 1928.
The growing point is enlarged and no evidence of flower primordia can be seen.

Fig. 2. First Series, June 25th, 1928.
Here the apex is seen to be broader and flatter than in Fig. 1.

Fig. 3. First Series, July 2nd, 1928.
In this section the first signs of primordia are seen, as small projections.

Fig. 4. Second Series, July 2nd, 1928.
As in Fig. 3, the primordia are developed.

Fig. 5. Second Series, July 9th, 1928.
The flower primordia at one side of the apex is much larger than in the previous week.

Fig. 6. Third Series, August 4th, 1928.
This shows flower primordia in an early stage of development.

Fig. 7. First Series, August 18th, 1928.
This shows the flower primordia at a more advanced stage, the sepals being well developed.

Fig. 8. Third Series, August 18th, 1928.
This bud shows the sepals being differentiated.

Fig. 9. Second Series, July 16th, 1928.
In Fig. 8 the third picking of the third series, the sepals are differentiated but in this section no evidence of sepals can be seen.

ROOT REGENERATION UPON TRANSPLANTED APPLE ROOTSTOCKS.

By Thomas Swarbrick.

Introduction.

During the previous studies at Long Ashton upon the normal physiology of the shoot system of apple trees, it was realised that a more detailed knowledge of the manner and periodicity of root growth was urgently needed. In view of the practical difficulties involved in the investigation of roots and root systems, this part of the tree has not been so fully investigated as the above ground parts. As a consequence our knowledge of root growth is not so full as that of shoot and stem growth.

A preliminary survey of the problem involved reveals the fact that there are two general phenomena to be investigated, firstly, the periodicity of new root formation and growth as evidenced by linear extension and, secondly, the thickening of the roots, *i.e.* cambial activity. They are, of course, intimately related to each other, but at this stage they may be regarded as separate problems for investigation.

The periodicity of new root formation and the elongation growth of roots is the more simple of the two problems to investigate since it does not necessarily involve the destruction of the plants under investigation. It is largely observational in character and deals with the morphological aspects of root growth. The second problem is more difficult and involves anatomical and histological examinations of material collected specifically for the purpose, which almost invariably involves the loss of the plant under investigation.

With regard to the first problem, endeavours are at present being made to develop a satisfactory technique of observing root growth *in situ* over a period of years. Pending this latter development the present preliminary experiment was carried out. It has as its immediate object the elucidation of the time and period of new root formation in newly transplanted apple stocks. This type of investigation is necessary since there is evidence at hand that, in the case of newly planted trees, root regeneration may show features that are lacking from the normal cycle of root growth in established trees. The time of planting has a profound influence upon the first year's root growth cycle.

PLATE I.

FIG. 1.

PLATE I.

FIG. 2.

PLATE II.

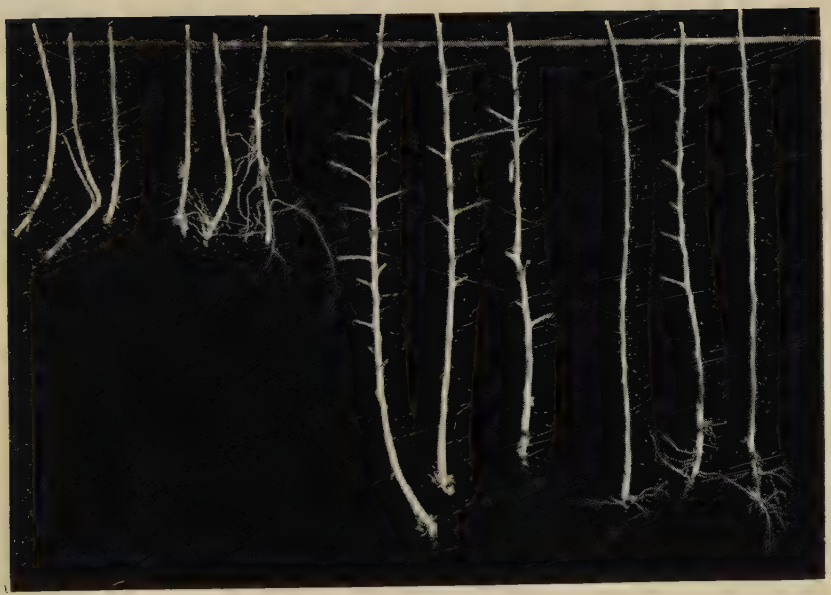

PLATE III.

Material and Methods.

For the present study current year's layers of Malling Type 13 root stock were used. This is a very vigorous and free rooting stock. It throws from the layered stems a large number of strong shoots which root readily when mounded up with soil during the early part of the growing season. This root stock, therefore, provides very suitable material for an investigation such as the present one.

On October 15th. 1928, 100 stocks of the root stock were taken from the stool beds. At this date the stocks were in full leaf, and were still making terminal extension shoot growth. They had, however, made quite large root systems (Plate I, Fig. 1). These root systems consisted of many fairly long " primary " roots arising directly from the stem. In many cases these " primary " roots had developed numerous " secondary " lateral outgrowths. The amount and type of root is very well shown in the illustration.

It will be realised that October 15th is a very early date upon which to remove stocks from the stool bed. This does not usually take place before the November-December period. The earliness of lifting and transplanting, however, was part of the general plan of the experiment, since it is already well known that stocks lifted during the November-December period, and transplanted in early spring, do not produce new roots until the March-April period of the following spring.

After removing the stocks from the stool bed, they were graded into two classes, the large and the small. This made two groups of about 60 and 40 plants respectively. Each grade was then divided into two lots and from one lot of each grade all the roots were removed as close to the stem as possible without cutting into the bark. The remaining two lots were not root pruned in any way. The stocks were then planted in four parallel rows in a plot of low fertility adjoining the laboratories. The soil was extremely close in texture and somewhat consolidated due to tramping. After planting, in order to reduce the water loss by excessive transpiration, the whole of the larger grade stocks were cut down to within 20 inches of the ground, and the small stocks to within 8 inches of the ground.

October 15th, 1928, was a rather warm, dry day. The stocks were removed from the stool bed during the morning and were planted during the afternoon. A piece of light sacking was thrown over the roots while they were out of the ground. In Plate I, Figs. 1 and 2, are shown photographs of the stocks as lifted and after being root pruned prior to replanting.

The material was lifted by digging at suitable intervals after planting, and examined for root regeneration.

Observations and Results.

On October 16th, which was the day following planting, the leaves of the larger stocks were very much bronzed. There was little evidence of wilting in the sense of the leaves becoming flaccid, but they had turned a dark rusty brown colour, were leathery in texture and very much curled up. There was no observable difference in the amount of browning or curling of the leaves between the stocks which had all roots removed, and those with no roots removed. The small stocks which had been cut back to within 8 inches of the ground often retained only two leaves, and these showed much less browning and curling than the leaves of the large stocks. This difference in the amount of browning of the leaves was much more evident at a week after transplanting. Within fourteen days after planting the leaves of both groups began to fall off.

First Root Examination—November 15th, 1928.

One month after transplanting, three stocks of each group were lifted for examination. These were dug out of the ground and, as a consequence, there was always more or less root damage, particularly as the soil was solid and hard. The damage usually consisted in the breaking away completely of young roots developing from the stem of the stock and the breaking of young succulent roots along their length.

At this date new root formation had already begun. New thick, fleshy, white roots of about $\frac{1}{4}$ to $\frac{3}{8}$ inch long had developed from the nodes of the stock stem below ground. Only on two of the six large stocks lifted were there no new roots present. On the rest the number ranged from two to six. At this stage there was no evident difference between the amount of new root regeneration on the root pruned and non-pruned stocks. If anything there was more pronounced root regeneration on the stocks which had all roots removed prior to transplanting.

The significant observation at this date was that new root formation had already begun.

Second Root Examination—18th January, 1929.

On this date a second batch of stocks was lifted for examination. During the previous fourteen days there had been very severe frost, the ground being frozen to considerable depths. On January 18th there was a thaw, but the ground at 6 inches deep was still partly frozen.

New root formation was more advanced and more in evidence than at the examination made two months earlier. The three large grade stocks which had all roots removed at planting and

which were lifted on January 18th, 1929, showed 15, 8 and 6 new roots developed from the stock. These new roots were mostly about ½ to ⅜ inch long, but there were several which were over an inch long. The stocks not having had the roots removed at planting showed decidedly less new root formation than those with roots all removed at planting. The old root of those not root pruned at planting had turned dark brown in colour, and had not increased to any appreciable extent in size or amount. In fact, many of the roots had died back for considerable distances. It was clearly evident at this time that the root pruned trees were making much more vigorous root regeneration. In the stocks not root pruned at planting, such new root growth as was taking place was in the development of thick, fleshy roots of the same character as those developing upon the root pruned group. (Plate II).

The smaller grade stocks showed the same kind of response as their larger fellows. It was, however, less in amount.

Third Root Examination—20th March, 1929.

A batch of stocks similar to that lifted in November and January was examined on March 20th, 1929. Taking the trees as a whole, they showed the same general features as were detailed in the previous section. New root growth in the form of thick fleshy white roots arising from the stem of the stock was much greater in the case of the stocks that had all roots removed at planting. In this case new roots were emerging from almost every node below ground level. The larger stocks showed more root regeneration than the small ones.

On this date, in addition to the features outlined above, the stocks with roots remaining at transplanting showed root regeneration at two positions and of two different kinds. There was the large, thick, fleshy, white, unbranched roots arising directly from the stem of the stock and there was also a large number of small, sharply pointed, new roots arising as laterals upon the old remaining root system. In point of numbers the latter was the greater.

On this date, no sign of bud growth was evident. The shoot still appeared to be completely dormant.

The root regeneration as small laterals upon the established root system not removed at planting, was, therefore, prior to and apparently independent of the exfoliation of the buds. It is perhaps also interesting to note that about this same time the writer had occasion to lift a considerable number of one year seedling apple trees which had been heeled in the ground since Christmas. Many of these seedlings showed a similar small lateral root regeneration upon the old established roots.

Fourth Root Examination—19th April. 1929.

A fourth batch of stocks examined on the 19th of April showed that root growth was proceeding rapidly. By this time the buds were opening and the first leaves were fully expanded. Considerable difficulty was experienced in lifting the stocks with roots complete as the young roots were succulent and very brittle. This examination showed that the root development which had occured since the previous examination was due to the growth of roots present at that time. There had been no recent significant initiation of new roots from the stock.

It was again evident that more vigorous root regeneration was taking place from the stocks which had all roots removed at the time of transplanting. In the case of those which were not root pruned at transplanting the root regeneration was from both the stem of the stock and from the established roots as described earlier.

Fifth Root Examination—28th May, 1929.

The batch of stocks lifted on May 8th, 1929, concluded the experiment. The stocks are shown in Plate III, and they exhibit several interesting features.

Root growth was both rapid and vigorous at this time. The new roots which began to arise from the stem of the stock during the period November to January were still white and succulent, and elongating rapidly and were still unbranched. There was, however, a distinct tendency for these roots to show browning of their surface at the parts approximate to the stem. These roots appeared to have a very uniform diameter along their entire length and to have very rounded blunt growing points. A further point of interest was the development of short lateral root initials upon the older parts of these " primary " roots. These lateral roots appeared as small, somewhat sharply pointed outgrowths. This V pointedness of the tips of these lateral roots was in marked contrast with the U roundness of the tips of the main " primary " roots. At this time these laterals cannot have been very old since they were not more than one-quarter to one-fifth of an inch long. Except that these laterals were more vigorous they were similar in appearance to the lateral root initials which appeared two months earlier upon the old root of the layers which were not root pruned at planting.

The trees with all roots removed at planting time were still developing their new roots very rapidly, but it was evident that the number was not increasing—that is fresh roots were not being initiated from the stem. Those already formed were developing in length.

At this time both sets of stocks, *i.e.* root pruned and not root pruned, had made very good root systems, but they were somewhat different in character. Those stocks which had all roots removed at planting had root systems that were entirely new, being made up of roots developed from the stems since planting. These roots were thick, fleshy, succulent, and unbranched and were beginning to develop laterals upon the older parts. The stocks which were not root pruned at planting had much larger root systems than the previous group, made up of new roots similar in every way to those comprising the total root system of the previous group in addition to the original root system which had developed a large number of short lateral roots about half an inch long. In no case was an " old " root observed to have developed a strong new leading root with a blunt tip.

At this time therefore the stocks which were not root pruned at planting, appeared to have the distinct advantage in the amount and feeding capacity of the root system. This was due to the development of new " primary " roots from the stem of the stock as well as to the development of short lateral roots upon the *original* root system. These new laterals did not develop into fleshy main roots, but remained as they started, somewhat thin and pointed. The new " primary " roots which developed from the stem showed every appearance of becoming the large, thick main roots of the mature tree.

Discussion.

It is not intended at this stage to enter into a long discussion of these observations, but rather to indicate some aspects of their bearing upon fruit culture.

It is realised that October 15th is a very early date upon which to remove layers from the stool bed. It is clearly demonstrated, however, that a distinct advantage may be obtained by such a procedure in that the layers were established and were making new root growth in their new quarters before winter began. Under certain conditions this may be a distinct advantage. In any case, the experiment bears directly upon the debated question of fall and spring planting of young fruit trees. Under the conditions of the present experiment there is no question that the October transplanting—notwithstanding the fact that the stocks were in full leaf—was most successful. The same stocks transplanted during the winter or in Spring 1929, could not have been so well established by the following winter. It is realised that in practice, fall or spring planting usually turns upon soil conditions, but from the theoretical and experimental standpoint the present work would support and favour early autumn transplanting.

It is also fully realised that Malling Type 13 rootstock is a very free rooting stock, and that others such as Type 12 and Type 9 may not respond so well to such early transplanting. Experiment alone can determine this point.

The question of the preservation of the established root system in transplanting is also touched upon. While in this experiment the more vigorous root regeneration took place from the stocks which had all roots removed at transplanting yet, in the following May, the trees which were not root pruned, Plate III, had the larger effective root system. Whether or not the newly developed root system of the root pruned layers will be ultimately the better because it is all new and vigorous, again experiment and observation alone can determine. It would seem, however, that until further evidence is available it is advisable to retain at least a fair amount of the original root system at transplanting.

The last point of particular interest at this stage is the difference in the growing points of the " lateral " and the main " primary " roots. The one is pointed at its apex and the root base is rather thin, the other is blunt and rounded and of larger diameter. The internal conditions governing this difference are not sufficiently known to permit of discussion at this point.

The initiation of new roots so early upon very early transplanted root stocks suggests that under favourable conditions and with free rooting stocks it may be possible to transplant stocks from stool beds in October and graft them the following spring. This would eliminate a year from the period of raising young trees and cheapen the cost of production.

The various points raised by this experiment are being followed up as opportunity affords. The subject is part of a larger investigation into the cycle of root elongation growth and its related phenomena the periodicity of secondary thicking in roots.

DESCRIPTION OF PLATES.

PLATE I.

Fig. 1. Showing typical stocks as lifted October 15th, 1928, and replanted without root pruning. Note the root characters and the presence of foliage.

Fig. 2. Showing typical stocks of the root-pruned series, October 15th, 1928.

PLATE II.

Showing the root systems of the stocks lifted January 18th, 1929. Note the amounts of new roots in the four groups.

Order from left to right : small stocks with all roots removed at transplanting ; small stocks with no roots removed ; large stocks with all roots removed ; large stocks with no roots removed.

PLATE III.

Showing the root systems of the stocks lifted May 18th, 1929. Note the vigorous root growth in group 3 and fair growth in group 1 ; also the development of new fleshy roots from the stems of the stocks in groups 2 and 4.

Order as in Plate II.

POT EXPERIMENTS ON THE MANURING OF FRUIT TREES—V.

THE EFFECTS OF DEFICIENCIES OF POTASSIUM, CALCIUM AND MAGNESIUM RESPECTIVELY ON THE CONTENTS OF THESE ELEMENTS AND OF PHOSPHORUS IN THE SHOOT AND TRUNK REGIONS OF APPLE TREES.§

By T. Wallace.

In the previous four papers of this series which appeared in the Annual Reports for the years 1921, '22, '23, '24, accounts were given of nutritional experiments on apple trees, gooseberry and black currant bushes and raspberry and strawberry plants in sand cultures.

The results reported related to the effects produced on shoot growth, foliage characters, blossoming, fruiting, defoliation phenomena and root characters by deficiencies of the various major "essential" elements and by varying ratios of $\frac{\text{Nitrogen}}{\text{Potassium}}$ and $\frac{\text{Potassium}}{\text{Magnesium}}$ in the diets of the plants. It was shown in those experiments that a deficiency of each of the elements considered produced well-defined effects and that the effects in each case were readily distinguishable and could be used by an experienced observer for diagnostic purposes.

In carrying out the experiments, it was not possible to make chemical studies on the plants utilised in the work, but since that time opportunities for such work have occurred and this branch of the investigations has been pursued.

In the experiments described in the present paper, the effects of deficiencies of potassium, calcium and magnesium on the contents of these elements and of phosphorus in the shoot and trunk regions

§ An abridged form of a paper entitled: "Experiments on the Manuring of Fruit Trees, III," published in the Journal of Pomology and Horticultural Science, Vol. VIII, No. 1 (1930).

of young apple trees have been examined. The primary objects of the work have been to ascertain the extent to which deficiencies of the three elements are reflected in the mineral contents of the various portions of the trees examined and to obtain information regarding methods of sampling trees in chemical studies.

The results reported show that deficiencies of the three elements considered are reflected in the composition of the mineral portions of the leaves and the bark and wood of both the shoot and main stem portions of the trees. They also show that in investigations of this type it is necessary to analyse bark and wood separately, since they differ markedly in composition, and especially where materials of different ages are concerned, when the proportions of bark to wood differ widely.

In addition to the above results, it has been possible in these experiments to distinguish more clearly the leaf characters resulting from calcium deficiency, and it was found that the variety of apple used appeared to be much more drastically affected by magnesium starvation than any variety used hitherto while potassium deficiency resulted in much larger shoot growth then in the complete nutrient series, a result not in accord with our previous experience.

Of the previous investigations which have been reported relating to the problems under consideration, mention may be made of the work of Butler, Smith and Curry (1) who examined the distribution of certain reserve materials and ash constituents in the various portions of apple trees, of Reed and Haas (3) who have studied the effects of certain nutrient treatments on citrus trees in sand and soil cultures, of Tufts (4) who has investigated methods of sampling shoots of peach, pear and apple trees in relation to the distribution of reserve materials and of the writer in investigations on chlorosis (6, 7) and on the effects of manurial treatments on the composition of gooseberry bushes.(8)

Experimental.

The trees employed in the investigation consisted of 80 maiden apple trees, variety, Stirling Castle, all worked on Malling Type I rootstock. They were divided into four groups of 20 each for the treatments " complete nutrient," " calcium omitted," " magnesium omitted," and " potassium omitted," and were planted during January, 1926, in a good quality quartz sand—99.5% insoluble in boiling hydrochloric acid—contained in 10in. unglazed, but previously waxed plant pots. Each pot contained 10 kilos of sand. The pots were fitted as previously described, (5, 9) with the exception that dome-shaped earthenware covers, previously waxed and each

with a hole 2in. in diameter through the centre, were used to cover the tops of the pots vice tarpaulin covers. This new type of cover was found to be more efficient than the old one both as a means of keeping out the rain and of preserving an even, low temperature in the sand medium.

The culture solution used as the " complete " nutrient solution differed from that originally used (5, 9) in that it contained approximately three times as much potassium and magnesium, twice as much calcium and no sodium. Details of its composition are as follows :—

	gms.
Potassium Nitrate	8.0
Potassium Chloride	1.0
Di-potassium mono-hydrogen phosphate (K_2HPO_4)	1.0
Calcium Sulphate	2.0
Magnesium Sulphate $7\,H_2O$	3.0
Ferric Chloride	0.4
Rain Water	to 1 litre.

One litre of the above solution was diluted with 9 litres of rain water previous to application.

The concentrations of certain of the elements as parts per million in the solution as applied are as follows : nitrogen 112, potassium 385, calcium 60, magnesium 30, phosphorus 17, iron 14.

In order to derive the various " omission " solutions from the " complete " solution, the salt (or salts) containing the element to be omitted was replaced by an equivalent amount of the corresponding sodium salt.

It should be pointed out that the " complete " solution is regarded as being definitely high in potassium and it seems possible that, for the particular variety of apple used, a solution lower in potassium would be more suitable.

The technique of tending the cultures was as followed in the previous work. Aphides were controlled by winter washing with a tar-distillate wash and any pests which appeared during the growing season were removed by hand or by means of a camel hair brush.

At planting all fibrous roots were removed from the trees and the stems were headed back to a length of approximately 20 inches. The first applications of the nutrient solutions were given on February 25th.

Samples of material for analytical purposes were obtained in the following way. The trees receiving each treatment were divided into 2 groups, one group being designated the " Summer Pruned Group " and the other the " Winter Pruned Group." In the

" complete " nutrient, potassium omitted, and calcium omitted series, the summer pruned group comprised 5 trees and the winter pruned group 15 trees, but in the magnesium omitted series both groups contained 10 trees as it was found in this last series that 5 trees were too few to supply the analytical material required from them.

The summer pruned trees were used to provide samples of shoots, comprising leaves and stems representative of the active growing season and the winter pruned groups to supply samples of shoots during the dormant period.

It was proposed originally to take the former samples in each season at the time when any one series should show signs of developing serious breakdown of the leaves and this plan was followed in the first two seasons, but, in the third, the magnesium omitted series collapsed at too early a date to obtain samples large enough from the summer pruned groups and thus, on this occasion, this series was treated in a special way, leaf samples only being taken at this early date, but from both the summer and winter pruned groups, and the remaining three series were sampled in the usual way at a later date when breakdown symptoms had commenced to show to a slight extent in all of them. The samples from the winter pruned trees were due to be taken when the trees appeared to be in a dormant condition and this procedure was adhered to in all seasons.

The summer pruned trees also received a winter pruning at the same time as the winter pruned samples were taken but the shoots removed on such occasions, which comprised all the new growth since the summer pruning, were not utilised for analytical purposes.

The shoots employed for the analyses in all cases comprised the whole of the shoot growth made during the season prior to the sampling operation, the growths being cut off at the points of junction with the main stem in each case.

In the summer pruned series, all leaves attached to the severed shoots were used in the analyses but several leaves were lost each year from wind damage prior to sampling.

Previous to taking all samples, the sand in the pots was brought to maximum moisture content, and all samples for comparison were taken within the space of a few minutes.

The summer shoots were divided into two parts, laminae of leaves and stems plus petioles, and the winter shoots into bark and wood.

The portions of the main stems of the trees above the stock and scion unions were analysed in bark and wood samples at the end of the experiment.

Throughout the duration of the experiment, detailed observations were made on the growth features of the trees.

Results.

Growth Features.

Complete Nutrient Series. All trees made good growth during 1926. The foliage was of excellent quality throughout the season, but small areas of dead tissue in the forms of spots and patches were present on the leaves to a slight extent from July 11th. Defoliation proceeded rapidly from October 26th.

The summer pruned series, subsequent to pruning, developed healthy shoots, which carried healthy foliage and grew to lengths of 2 inches to 3 inches.

During 1927 the amount of shoot growth made by the winter pruned series was approximately twice as great as in 1926. The foliage was generally of good quality, but dead patches of tissue were apparent to a small extent from June 22nd. Around July 10th. serious defoliation occurred from very high winds, in some cases shoots becoming 50% defoliated. Autumn defoliation proceeded rapidly from the beginning of October.

The growth made by the summer pruned series after pruning was similar to 1926 and the foliage borne was healthy.

In 1928 shoot growth was smaller than in the previous season. The foliage remained of excellent quality until June 11th when some wind damage occurred. This was followed by an aphis attack and in spite of much attention, by July 15th, the pest had caused serious defoliation in some trees. During this period dead patches on the foliage became fairly numerous and the most seriously affected leaves in some cases were shed. Autumn defoliation proceeded rapidly during the early part of October.

During the latter part of the season, approximately 20% of the shoots showed dead tips.

The summer pruned series made practically no shoot elongation subsequent to pruning, but carried healthy foliage until the end of the season.

Potassium Omitted Series.

The trees made good growth during 1926, being similar to that in the complete nutrient series, and carried excellent foliage through-

out most of the season. One tree developed severe leaf scorch about September 24th and others showed the trouble to a slight extent during October. Defoliation occurred a little later than in the complete nutrient series.

The growth features in the summer pruned group were similar to those in the corresponding group in the complete nutrient series.

During the second season, the winter pruned trees made considerably larger shoot growth than in the complete nutrient series. The foliage until early July was of excellent appearance, but from this time leaf scorch developed and on July 10th two trees showed severe scorch and five trees slight amounts. It was evident that the gales at this period caused much less defoliation than in the other series. (See also 1928 notes). All trees showed severe scorch and had lost approximately 20% of their foliage by September 12th whereas, on this date, in the complete nutrient series, defoliation amounted to approximately 50%. It was notable that defoliation was proceeding generally in the direction from the tips of the shoots downwards towards the crotch, in contrast to the other series where defoliation proceeded in the opposite direction. This method of defoliating in cases of potassium deficiency is common and is a useful diagnostic feature. Many dead tips were noted in the shoots from September 12th and, at the end of the season, it was found that, of a total of seventy-four shoots, twenty-two showed dead tips. This did not occur in any other series during 1927. General defoliation of this series occurred at a later date than in the complete nutrient series, defoliation varying from 40% to 80% on October 6th in the series whereas, on that date, the trees in the complete nutrient series mostly retained only tip rosettes of leaves.

The growth features of the summer pruned series were similar to those in the complete nutrient series.

In 1928, the trees in this series again made larger shoot growth, being practically the same as in 1927. The growth features were similar to those in 1927, the foliage remaining healthy until leaf scorch appeared in early July. The gales in June did not cause much damage to the foliage, but aphis damage in July caused rather serious effects on some trees. All trees showed severe leaf scorch by the end of August, but there were never any signs of spots of patches of dead tissue on the leaves, such as became serious in the other series, especially in the calcium and magnesium omitted series. Indeed it seems highly probable that the spotting and patching effects are related to high potassium feeding. Defoliation occurred later than in the other three series, the trees retaining 50%

of their foliage on October 14th whereas in the other series only tip rosettes were retained. The direction of defoliation was again from tips downwards. Of 84 shoots, 15 showed dead tips after defoliation.

The summer pruned trees in this series were the only ones to make any shoot growth after the summer pruning, shoot lengths from 2 inches to 6 inches being made, whilst the foliage carried on these was as healthy as in the complete nutrient series.

Calcium Omitted Series.

The shoot growth made by the trees in this series during 1926 was somewhat larger than in the complete nutrient series, and it was notable that the leaves were larger in size. The quality of the foliage was also similar to that in the complete nutrient series, but patches of dead tissue were slightly more frequent in the calcium omitted series. Defoliation phenomena were similar in the two series, as also was the behaviour of the trees in the summer pruned groups.

In 1927 shoot growth was again definitely larger than in the complete nutrient series, although somewhat smaller than in the potassium omitted series. The leaves were again observed to be rather larger in size than in the complete nutrient series from about the middle of June. Dead patches both near the centres and margins of the leaves were observed from June 3rd and, by July 10th, these breakdown patches were very prevalent. About that time, severe defoliation occurred from the high winds and from then to the end of the season, the trees behaved as in the complete nutrient series.

The trees in the summer pruned group, subsequent to pruning, were similar to those in the complete nutrient group, but from September 12th the leaves showed dead patches.

In the last season, shoot growth was also slightly larger than in the complete nutrient series and, throughout the season, the general growth characters in the two series were similar excepting that, in the calcium omitted series, larger leaves were developed and, from July 4th, dead patches on the leaves were much more prevalent. By August 30th, this break-down was very severe and the foliage was in poor condition. Detailed notes were made on the forms of breakdown on that date when three main forms were distinguished.

a. The typical centre " blotch " as previously described in connection with magnesium deficiency.(5)

b. Marginal effects resembling leaf scorch in which cases the texture of the affected portions appeared to be very thin and brittle.

c. Irregularly shaped patches extending either from the tips or from points on the margins.

Defoliation occurred simultaneously with the complete nutrient series. After defoliation it was found that 10 shoots of a total of 78 showed dead tips.

The summer pruned trees made very poor growth after pruning. They failed to make any shoots, only rosettes of leaves of very thin, delicate texture being developed. These showed severe breakdown by August 20th and were all dying off on October 14th, at which time the foliage in the complete nutrient and potassium deficient series appeared quite healthy.

Magnesium Omitted Series.

The treatment given to this series produced very drastic effects on shoot growth and foliage characters from an early date.

In the first season, shoot growth and foliage characters were very similar to those in the calcium omitted series until July 29th, both shoots and leaves tending to be large. By June 28th, patches of dead tissue began to appear on the older leaves and, by July 11th, the affected leaves commenced to be shed. The extent of the breakdown was very severe by July 29th and from this date defoliation proceeded rapidly. On September 24th, only tip rosettes were retained.

Shoot growth was greatly restricted in the summer pruned group after pruning and in early October the foliage showed much patch dying.

In 1927 shoot growth was very poor and the foliage was in poor condition from an early date. The first breakdown was noted on May 26th and, by June 3rd, the leaves were notably pale and showed much dying in patches both near the centres and margins. By June 22nd, the foliage was in very poor condition and many shoots were approximately 50% to 60% defoliated, the younger leaves having a somewhat chlorotic appearance. Only tip rosettes and occasional older leaves in poor condition were retained on July 10th. The summer pruned group produced practically no shoot growths after pruning and the leaves which developed were pale green in colour, and thin and delicate in texture. They developed breakdown symptons at an early stage and many were shed by September 12th.

In the last season, many of the trees in this series were unable to make any appreciable amount of healthy growth. On May 10th, it was observed that shoot growth was much behind that in the other series and, in many cases, only rosettes had been formed. By May 25th, breakdown of foliage was very severe and within the course of the following week, much defoliation took place. The leaves were often slightly chlorotic, the texture was very thin and delicate, and breakdown took the form of dead patches as described under the calcium omitted series.

In view of the condition of the trees, samples of foliage were collected for analysis from all except one tree on June 4th. During the remainder of the season, the trees continued to develop successive series of leaves which usually collapsed and were shed when they were about 1 inch in length.

In connection with the above observations, it seems necessary to point out that the types of leaf breakdown developed in the three series, complete nutrient, calcium omitted and magnesium omitted were similar in appearance, although the extent of the breakdown in the last series was much greater than in the other two and was also greater in the calcium omitted series than in the complete nutrient series. The development of the dead patches along the margins in some cases is of interest, as in previous work, using the varieties Cox Orange Pippin, Allington and Worcester, the breakdown due to magnesium deficiency has been developed much more definitely in the centre portion of the leaves as "Blotch." In an experiment still in progress, using the variety Bramley's Seedling, it has also been observed that the breakdown symptoms for the treatments calcium omitted and magnesium omitted are similar, but that the extent of breakdown in the case of the magnesium omitted series is much more serious than in the calcium omitted series while, in the latter series, a much larger proportion of the patches occur at or near the leaf margins.

Chemical Data.

From the results of the chemical analyses made, Table I has been constructed which shows the effects of the respective deficiency treatments on the contents of CaO, MgO, K_2O and P_2O_5 in the Dry Matter of the various portions of the trees.

TABLE I.

Showing effects of the various Deficiency Treatments on Amounts of Calcium, Magnesium, Potassium and Phosphorus in Dry Matter. The Amounts of the Elements in the Various Series are shown as percentages of the Amounts of the respective Elements in the Complete Nutrient Series for each Sampling.

a. Summer Pruned Series.

Material and Series.	Dates of Sampling	CaO %	MgO %	K_2O %	P_2O_5 %
LEAVES.					
Potassium Omitted	29/7/26	141.5	151.9	**34.63**	116.9
	13/6/27	148.0	78.52	**37.18**	115.9
	7/7/28	238.8	249.6	**19.62**	91.5
Calcium Omitted	29/7/26	**87.80**	96.42	104.6	113.8
	13/6/27	**86.09**	107.7	109.7	105.8
	7/7/28*	**67.14**	92.96	83.8	48.5
Magnesium Omitted	29/7/26	101.4	**48.93**	104.6	110.6
	13/6/27	103.9	**41.91**	123.4	140.9
	7/7/28	149.1	**39.22**	124.7	146.1
STEMS AND PETIOLES.					
Potassium Omitted	29/7/26	107.3	106.5	**48.97**	119.6
	13/6/27	113.2	108.0	**38.66**	86.8
	7/7/28	156.5	139.8	**29.28**	98.9
Calcium Omitted	29/7/26	**84.41**	91.87	130.9	108.1
	13/6/27	**88.08**	115.2	114.1	53.7
	7/7/28	**94.23**	112.8	105.8	100.9
Magnesium Omitted	29/7/26	141.5	**51.31**	117.0	106.4
	13/6/27	168.4	**55.46**	110.0	59.1

* Results this series, on this date, probably low due to error in determining "ash in dry matter."

I. b. Winter Pruned Series.

Material and Series.	Dates of Sampling	CaO %	MgO %	K_2O %	P_2O_5 %
BARK.					
Potassium Omitted	9/1/28	146.3	169.9	**52.52**	146.0
	3/12/28	132.3	170.4	**38.94**	129.1
Calcium Omitted	9/1/28	**67.89**	114.3	103.9	108.3
	3/12/28	**56.70**	121.1	91.75	107.0
Magnesium Omitted	9/1/28	189.9	**40.8**	103.7	111.9
WOOD.					
Potassium Omitted	9/1/28	105.0	111.0	**34.73**	108.0
	3/12/28	125.7	105.2	**31.85**	115.8
Calcium Omitted	9/1/28	**57.01**	111.9	111.0	100.0
	3/12/28	**59.91**	100.7	84.1	99.3
Magnesium Omitted	9/1/28	142.5	**56.44**	109.9	124.5

I. c. Main Stems.

Material and Series.	Dates of Sampling	CaO %	MgO %	K_2O %	P_2O_5 %
SUMMER PRUNED.					
BARK.					
Potassium Omitted	3/12/28	152.0	106.9	**14.79**	97.54
Calcium Omitted	3/12/28	**86.88**	110.7	102.9	86.00
Magnesium Omitted	3/12/28	155.5	**41.23**	81.93	70.49
WOOD.					
Potassium Omitted	3/12/28	118.7	108.7	36.48	98.74
Calcium Omitted	3/12/28	**78.7**	130.8	208.3	75.08
Magnesium Omitted	3/12/28	127.0	**52.94**	216.3	55.05
WINTER PRUNED.					
BARK.					
Potassium Omitted	3/12/28	177.1	104.0	**42.63**	128.6
Calcium Omitted	3/12/28	**78.7**	112.8	110.1	105.8
Magnesium Omitted	3/12/28	108.9	**39.5**	73.47	97.1
WOOD.					
Potassium Omitted	3/12/28	109.4	123.1	**41.16**	119.5
Calcium Omitted	3/12/28	**72.2**	104.5	120.5	98.7
Magnesium Omitted	3/12/28	114.0	**34.7**	111.8	84.2

The main conclusions formed from the complete chemical data were as follows :—

1. All three omission treatments were reflected in the composition of the ash of all parts of the trees examined—leaves and stems plus petioles of summer pruned shoots, bark and wood of winter pruned shoots and bark and wood of the main stems. Large reductions in K_2O and MgO contents were effected in all materials by the omission of these bases, but the omission of CaO did not produce such large reductions.
2. Omission of any one of the three elements usually resulted in higher percentages of the other two in both the ash and dry matter.
3. Omission of K_2O or CaO generally resulted in the production of high percentage dry matter in fresh material and low percentage ash in dry matter while the reverse effects resulted from the omission of MgO.
4. The respective omissions possibly affected the content of P_2O_5 in dry matter in the various parts of the trees, the percentage being generally high in the leaves and shoot portions and low in the main stems.

5. In examining the effect of omissions of K_2O, CaO and MgO on the contents of ash constituents in trees, it is important to calculate the amounts on a basis of dry matter and not on the ash, since the percentage ash in dry matter in the cases of omissions of K_2O and CaO was found to be relatively low and in the case of MgO omission to be relatively high.

6. The contents of the ash constituents in the bark and wood of shoots and main stems differ widely, due to the ash content of the bark being much higher than that of the wood. The ash content was relatively uniform in the bark from the shoot and stem portions of the trees, but the percentages of ash in the wood of the shoots, one year old, were approximately twice as high as in the wood of the four year old stems.

7. In view of the results obtained for bark and wood, it is essential to consider them separately in examining the composition of shoot and stem portions of trees.

References.

(1) Butler, O. R., Smith, T. O. and Curry, B. E. "Physiology of the Apple." *New Hampshire Agric. Expt. Stn,*; *Bull.* No. 13 (1917).

(2) Mann, C. E. T. "The Physiology of the Nutrition of Fruit Trees—I." *Univ. of Bristol Agric. and Hort. Res. Stn. Annual Report.* 1924.

(3) Reed, H. S. and Haas, A. R. C. "Growth and Composition of Orange Trees in Sand and Soil Cultures." *Jour. Agric. Res.*, Vol. XXIV, No. 9, pp. 801-814 (1923).

(4) Tufts, W. P. "The Effect of Method of Sampling on the Results of Chemical Analysis of Horticultural Plants." *Proc. Amer. Soc. Hort. Sci.*, 1925, pp. 232-236.

(5) Wallace, T. "Experiments on the Manuring of Fruit Trees, I and II." *J. of Pomol. and Hort. Sci.*, Vol. IV, Nos. 3 and 4, and Vol. 5, No. 1 (1925).

(6) —— "Investigations on Chlorosis of Fruit Trees, II." *Ibid.*, Vol. VII, No. 3 (1928).

(7) —— "Investigations on Chlorosis of Fruit Trees, III." *Ibid.*, Vol. VII, No. 3 (1928).

(8) —— "The Effects of Manurial Treatments on the Composition of Gooseberry Bushes." *Ibid.*, Vol. VII, Nos. 1 and 2 (1928).

(9) —— "Pot Experiments on the Manuring of Fruit Trees." *Univ. of Bristol Agric. and Hort. Res. Stn. Annual Report*, 1921, pp. 42-57.

EXPERIMENTS ON THE EFFECTS OF LEACHING WITH COLD WATER ON THE FOLIAGE OF FRUIT TREES.*

I. THE COURSE OF LEACHING OF DRY MATTER, ASH AND POTASH FROM LEAVES OF APPLE, PEAR, PLUM, BLACK CURRANT AND GOOSEBERRY.

By T. Wallace.

In a previous paper, Mann and the writer (1) described experiments on the effects of leaching with cold water on the foliage of certain varieties of apple trees and showed that relatively large percentages of dry matter, ash constituents and potash (especially this last) could be leached from the leaves of these by immersing either detached leaves or leaves attached to terminal shoots in distilled water at ordinary room temperatures for periods varying from 24 hours to 72 hours.

Evidence was also presented to show that, in an extremely wet season such as 1924, leaching of foliage apparently occurred in the field in the cases of certain varieties to serious extents, leading to the ultimate death of a considerable amount of the damaged leaves.

Since the previous communication, the investigations have been extended to the examination of the leaching of foliage of certain varieties of pears, plums, black currants and gooseberries and further data have been secured on four varieties of apples. In these experiments the progress of the leaching of dry matter and ash has been followed in addition to the course of the leaching of potash.

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* An abridged form of a paper which appeared in the J. of Pomol. and Hort. Sci., Vol. VIII, No. 1 (1930).

(1) Annual Report, 1925, p. 17.

The results obtained on apples are in harmony with those previously reported, whilst those reported for the other classes of fruits show that the foilage of all behaves in a similar manner to that of the apple when subjected to the leaching treatment.

Experimental.

The whole of the experimental work was carried out during the season 1927.

In selecting the various samples for these investigations, a preliminary list of varieties of each class of fruit was prepared, which it was thought included some likely to leach easily and others likely to prove more resistant to the treatment. It was also proposed that, in the case of each class of fruit, the material of the varieties employed should be taken from trees or bushes of fairly comparable age.

As it was necessary to obtain the material in the Research Station plantations, it was found impossible to adhere to the initial proposals. Thus, in the case of apples, suitable trees of Cox's Orange Pippin, a variety very readily leached, were not available and the trees of Stirling Castle employed were younger than the other three varieties used ; of plums, it was proposed to include the hardy variety Pershore Egg and the less hardy variety Purple Pershore, and Victoria could not be obtained of comparable age to the other three varieties used ; of the black currants available, Seabrook's Black was younger than the other three varieties ; among the gooseberries, a suitable sample of Whinham's Industry could not be obtained. It will be seen from Table I that, apart from the exceptions mentioned above, the ages of the varieties in each class of fruit were identical. The notes on the samples employed also show that in all cases the leaves were of healthy appearance and seemed to be in excellent condition with the exception of Josephine de Malines, which variety produces foliage of poor quality in the Station plantations and which was selected as being likely to leach readily.

Materials.

Particulars of the trees and bushes from which material was taken are given in Table I, and the details of the materials used are shown in the notes on next page.

TABLE I.

Particulars of Trees and Bushes Used.

Class of Fruit and Variety	Date of Planting	Remarks.
APPLES.		
Allington Pippin ..	Autumn 1919	Vigorous trees, clean cultivated and highly manured.
Stirling Castle	„ 1923	do.
Bramley's Seedling ..	„ 1919	do.
Edward VII	„ 1919	do.
PEARS.		
Winter Nelis	„ 1922	do.
Williams Bon Chrêtien ..	„ „	do.
Conference	„ „	do.
Josephine de Malines ..	„ „	do.
PLUMS.		
Victoria	„ 1918	do.
Monarch	„ 1913	Fairly vigorous trees, clean cultivated and highly manured.
Rivers Early Prolific ..	„ „	do.
Ponds Seedling	„ „	Vigorous trees, clean cultivated and highly manured.
BLACK CURRANTS.		
Seabrook's Black ..	„ 1924	do.
Baldwin (Hereford strain)	„ 1922	Medium vigour; clean cultivated, manured wholly with artificials.
Edina	„ „	Vigorous; manured wholly with artificials.
Boskoop Giant	„ „	do.
GOOSEBERRIES.		
Leveller	„ 1924	Vigorous bushes; clean cultivated and manured with artificials.
Keepsake	„ „	do.
Lancashire Lad	„ „	do.
Yellow Sulphur	„ „	do.

DETAILS OF MATERIALS USED.

APPLES:

Allington Pippin.—Sample taken July 6th. A portion at 3 p.m. and remainder at 6.45 p.m. Healthy leaves of mature appearance taken from current season's shoots.

Stirling Castle.—Sample taken July 6th at 4.30 p.m. Leaves large and in excellent condition; a few showed slight spotting. Sample from mature leaves of current season's shoots.

Bramley's Seedling.—Sample taken July 18th at 3 p.m. Leaves large and in excellent condition; mature leaves from current season's shoots.

Edward VII.—Sample taken July 12th at 2 p.m. Healthy leaves of mature appearance from current season's shoots.

PEARS :

Winter Nelis.—Sample taken July 6th at 4.15 p.m. Mature leaves from current season's shoots and in excellent condition.

Williams' Bon Chrêtien.—Sample taken July 6th at 4.30 p.m. Conditions, etc., as Winter Nelis.

Conference.—Sample taken July 12th at 2.30 p.m. Mature leaves from current season's shoots and in good condition.

Josephine de Malines.—Sample taken July 25th at 3.15 p.m. Leaves were small; condition was only medium and in order to obtain a fairly good sample, the leaves taken varied somewhat in shape and age.

PLUMS :

Victoria.—Sample taken June 28th at 11 a.m. Mature leaves from spurs near current season's terminals. Generally excellent condition, but some had holes in them of "Shot-hole" type. Unable to take leaves from current season's shoots owing to aphis effects.

Monarch.—Sample taken July 12th at 3 p.m. Mature leaves from current season's shoots; excellent condition but rather below normal size for the variety.

Rivers Early Prolific.—Sample taken July 18th at 12.30 p.m. Mature leaves from terminal shoots and in excellent condition.

Pond's Seedling.—Sample taken July 12th at 3.15 p.m. Mature leaves from current season's shoots and in excellent condition.

BLACK CURRANTS :

Seabrook's Black.—Sample taken July 6th at 12 noon. Mature leaves on basal sections of current season's shoots and in excellent condition.

Baldwin.—Sample taken July 18th at 3 p.m. Condition, etc., as Seabrook.

Edina.—Sample taken July 25th at 12 noon. Condition, etc., as Seabrook.

Boskoop.—Sample taken July 12th at 2.45 p.m. Condition, etc., as Seabrook.

Gooseberries :

Leveller.—Sample taken June 28th at 12.30 p.m. Mature leaves from current season's shoots, in excellent condition and very large. A little lead arsenate on under surfaces.

Keepsake.—Sample taken July 6th at 12.30 p.m. Mature leaves from current season's shoots and in excellent condition. A little lead arsenate on under surfaces.

Lancashire Lad.—Sample taken July 12th at 3.30 p.m. Condition, etc., as Keepsake.

Yellow Sulphur.—Sample taken July 18th at 12 noon. Condition, etc., as Keepsake.

Note.—In all cases the leaves were taken on bright days and were always dry.

Methods.

The methods employed were identical with those used in the previous work.

Two samples of leaves, each weighing approximately 20 grms., were taken in each case. One of these was used as a control and determinations of dry matter, ash and potash carried out on it without leaching treatment. The second sample was employed in the leaching test. In all cases the freshly gathered leaves were conveyed to the laboratory without delay in large beakers, each beaker being covered with grease-proof paper. The petioles were removed and only the laminae used in the determinations. The leaching treatments were carried out in cylinders of 1 litre capacity, the laminae being placed in the cylinders and distilled water added to the 1000 c.c. mark. Each cylinder was then covered with a glass cover and placed in a cool position in the laboratory for 24 hours, the leaves being moved slightly in the water with a copper wire on three or four occasions during the period to ensure exposure of the leaf surfaces to the liquid.

In all cases four successive leachings of 24 hours' duration were given.

Results.

During the course of the leaching treatments, detailed observations were made on the appearance of the leaves and the extracts which resulted. These showed that, except in the cases of the black currant varieties and the Victoria plum, the treatments produced considerable effects on the leaves, the green colour often

being entirely destroyed—sometimes as the result of a single leaching—whilst the extracts at some stage of the leachings were coloured, the colours varying from green to brown.

These observations thus indicated the resistant nature of the black currant leaves and those of the Victoria plum, and these observations are confirmed by the analytical results.

The data secured for the leached leaves and the control leaves indicated that the degree of recovery effected in the determinations of dry matter, ash and potash from the leachings and residues in each leaching experiment was satisfactory, though, in a few cases, losses in dry weight occurred due to the breaking off of small portions of leaves during filtration and to charring in drying the leached fractions.

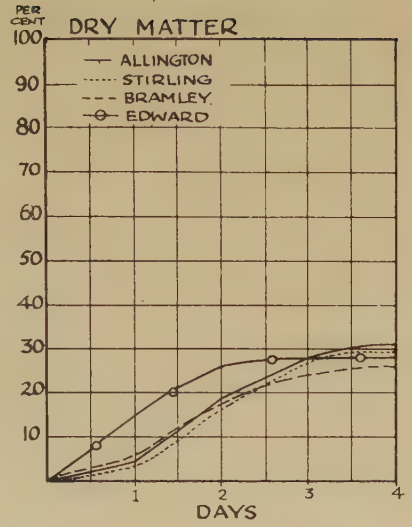
The analytical results have been summarised in graphic form in Figures 1 to 15 to show the course of the leaching of dry matter, ash and potash in the various cases.

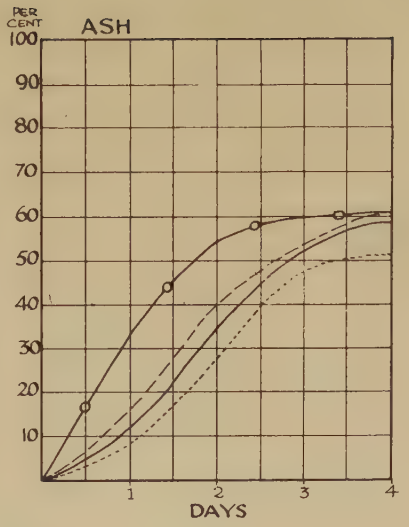
The salient points which emerge from the data are as follows :—

The percentages of dry matter leached from the apple varieties range from 25.55% to 30.37% ; from the pears the range is from 24.94% to 36.20%—Josephine de Malines showing a high value ; values for plums are only available for three varieties, the range being from 20.19% to 31.32%, Rivers Early Prolific yielding a low percentage, whilst it is also clear that Victoria would have given a much lower value than Rivers ; the black currant varieties all yield low percentages in comparison with the other classes of fruits—especially Seabrooks and Baldwin—the range being from 6.65% to 18.44% ; the range for the gooseberry varieties is very similar to that of the apple varieties, being from 26.91% to 30.21%.

The percentages of ash which are leached are always considerably higher than the percentages of dry matter removed, showing that a larger proportion of ash than of dry matter is readily soluble in cold water. The ratios $\frac{\%\text{ ash leached}}{\%\text{ dry matter}}$ leached are not similar for all the classes of fruits. Thus in the cases of the apple and gooseberry varieties, this ratio is approximately 2.0, but in the case of the black currant varieties it is approximately 3.0, for the pears approximately 1.5 and for the plums 1.7.

Here again the results show notable features both for the different classes of fruits and for certain varieties. The percentages leached from the apple varieties range from 51.31% to 60.31%, with Stirling showing a low value ; the pear varieties show a large


PER CENT
DRY MATTER
ALLINGTON
STIRLING
BRAMLEY
EDWARD
100
90
80
70
60
50
40
30
20
10
1
2
3
4
DAYS


PER CENT
ASH
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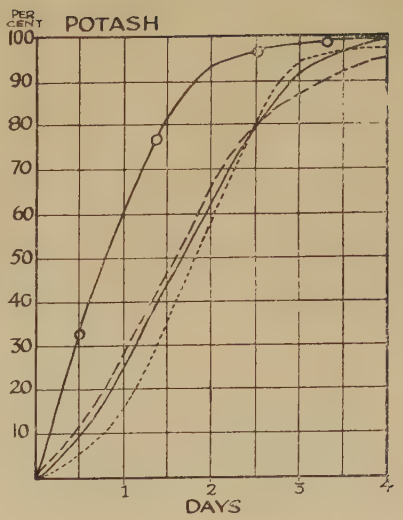
DAYS


PER CENT
POTASH
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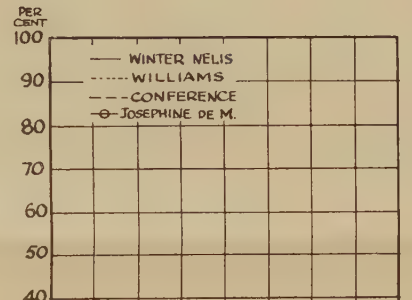
DAYS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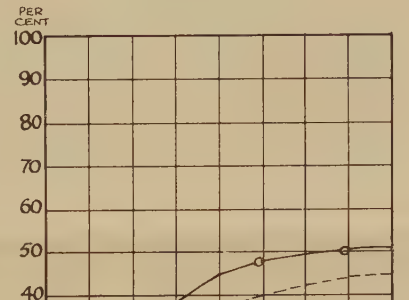
WINTER NELIS
WILLIAMS
CONFERENCE
JOSEPHINE DE M.
100
90
80
70
60
50
40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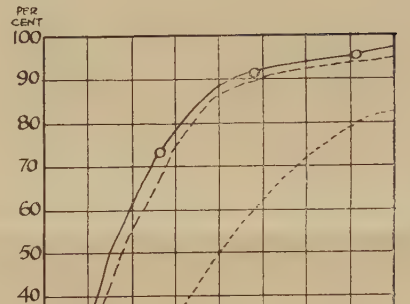
PER CENT
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50
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1
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3
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DAYS

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DAYS

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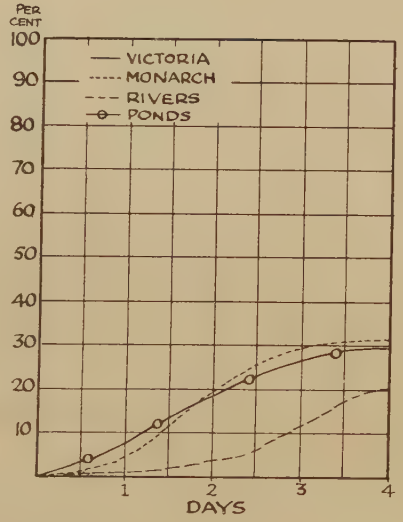
DAYS


PER CENT
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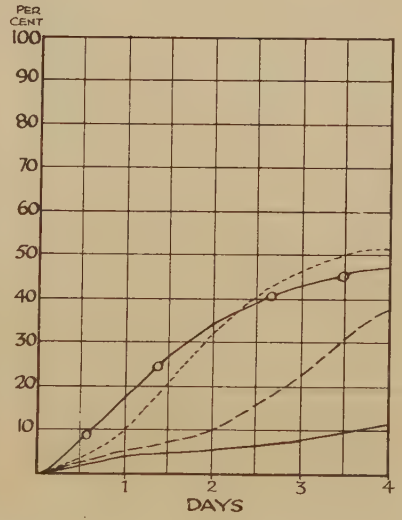
20
10
VICTORIA
MONARCH
RIVERS
PONDS
1
2
3
4
DAYS


PER CENT
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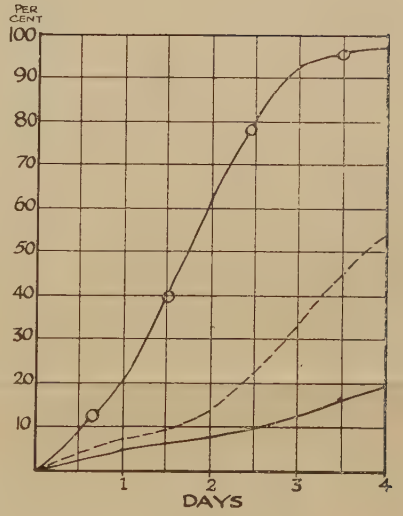
DAYS


PER CENT
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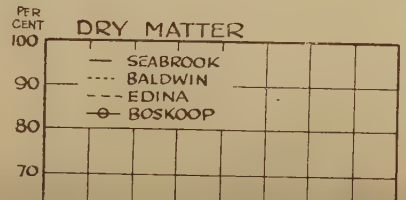
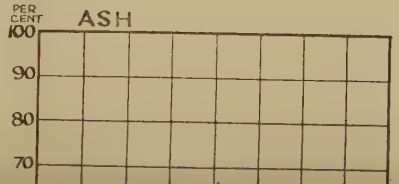
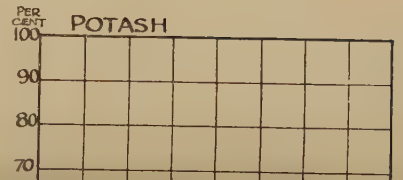
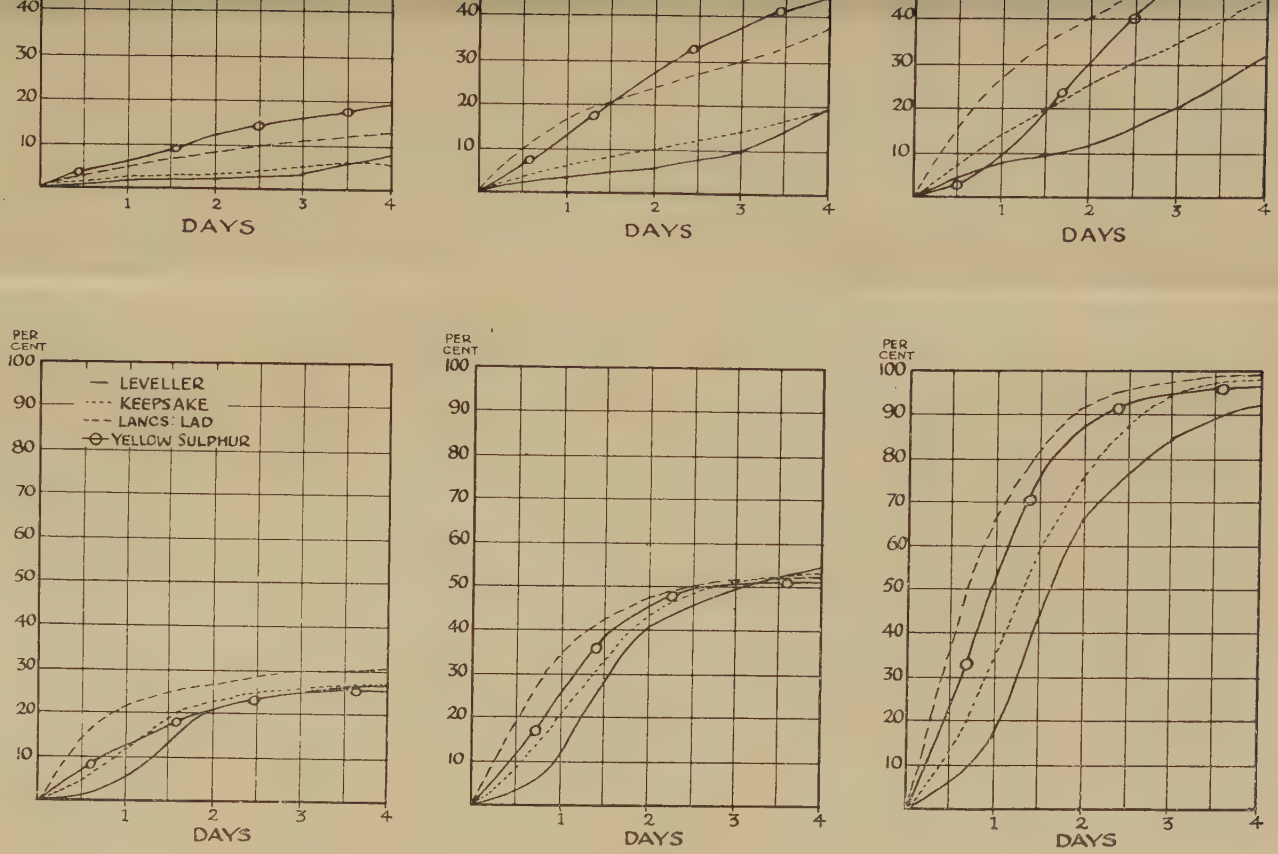
60
50
40
30
20
10
1
2
3
4
DAYS


PER CENT
DRY MATTER
100
90
80
70
SEABROOK
BALDWIN
EDINA
BOSKOOP


PER CENT
ASH
100
90
80
70


PER CENT
POTASH
100
90
80
70



FIGURES 1-15.

Summation Curves showing the Course of Leaching from the Leaves of Dry Matter, Ash and Potash respectively in four consecutive Leachings of 24 hours.

range, 35.44% to 50.78%, Williams being relatively low and Josephine high; in the plum varieties, the result for Victoria is notable, being only 10.97%, and the value for Rivers is also low; the values for the black currant varieties are again low, ranging from 19.70% to 43.75%, and show the two well-marked groups; the gooseberry varieties show a very narrow range, from 51.71% to 54.40%.

The percentages of potash leached are considerably higher than percentages of ash removed. In the cases of the apple and gooseberry varieties, practically the whole of the potash was obtained in the leachings. Of the three pears for which values were obtained, Josephine and Conference had lost nearly the whole of their potash by leaching, whilst Williams had also lost over 80%; the values obtained for the plums show an enormous range, the resistant Victoria had only lost 19.31%, whilst 96.55% had been removed from Pond's Seedling; the black currant varieties show a wide range and the two groups are again obvious. The ratios $\frac{\%\text{ potash leached}}{\%\text{ ash leached}}$ show variations both for classes of fruits and varieties.

The smooth nature of the summation curves showing the course of leaching of dry matter, ash and potash show that the process of leaching for each of these is continuous, while the similarity in shape for each of these in any variety indicates that, in all probability, the same groups of materials are being leached at all times during the period of leaching. The most common form of curve is the sigmoid indicating that leaching proceeds most rapidly during the middle periods and falls off during the final stages when the supplies of readily leachable material become comparatively scarce.

The ratios of the percentages of $\frac{\text{potash}}{\text{ash}}$ and $\frac{\text{ash}}{\text{dry matter}}$ leached and the similarities and differences in the behaviour of the various classes of fruits and the different varieties are also clearly shown by the curves.

Conclusions.

1. Healthy leaves of varieties of apples, pears, plums, black currants and gooseberries, when subjected to leaching by immersing the laminae in distilled water contained in glass cylinders of 1 litre capacity and retained in this way at laboratory temperatures for four successive periods of 24 hours, lost considerable proportions of potash, ash and dry matter by leaching.

2. The proportion of potash leached was greater than the proportion of ash and the proportion of ash greater than the proportion of dry matter.

3. The ratios of $\frac{\%\text{ potash}}{\%\text{ ash}}$ and $\frac{\%\text{ ash}}{\%\text{ dry matter}}$ leached varied for the different classes of fruits and for the different varieties.

4. All varieties of apples and gooseberries were readily leached; pears were also fairly readily leached; the plum varieties showed much variation, Victoria being extremely resistant to leaching; as a class, black currants were the least readily leached, and especially the varieties Seabrook's Black and the Herefordshire Baldwin.

5. Summation Curves show that the leaching processes were continuous and the shapes of the curves for potash, ash and dry matter in the case of each variety suggest that the same groups of materials were leached throughout the leaching periods.

THE SHAPE AND QUALITY OF APPLES IN RELATION TO THEIR POSITION IN THE FRUIT CLUSTER.

Progress Report.

By J. C. Hinton and T. Swarbrick.

Introduction.

During the spring of 1929 an investigation into the possible factors that affect the growth and quality of individual apples upon the same tree was begun at Long Ashton. It was fully expected that the work would extend over several seasons before any definite conclusions were possible. During the summer of 1929 and the storage period of 1929-30 two very interesting and important facts were brought to light which, in view of the lengthy nature of the main investigation, it seems desirable to record at this stage. Their bearing upon general fruit practice and the fundamental problems of plant physiology are being further examined at Long Ashton.

The investigation began as an attempt to elucidate some of the factors that underlie the well known fact that it is not possible to get a uniform sample of fruit either for size or quality from any single tree. The total crop "grades" from good to poor. In view of the developing practice of fruit thinning it is important to know where upon the tree the lower grade fruit is produced, so that it may be eliminated as much as possible during the operations that are carried out as routine treatments in orchard management.

In order to obtain the necessary working ideas, a large number of fruits were individually labelled upon selected trees immediately following "June drop." Trees of the variety Allington Pippin were used in this study. The following individual records were kept of each fruit :—

(*a*) The position of the fruit upon the cluster, *i.e.*, whether it was developed from the terminal flower of the cluster or from a lateral flower.

(*b*) The type and age of wood whence the blossom cluster was developed, *e.g.*, spurs upon two, three, four, or five year old wood; terminal blossom clusters upon 1928 shoot growth; lateral blossom clusters upon 1928 shoot growth.

(*c*) The number of fruits set and carried up to "June drop" by each cluster.

(*d*) Weekly measurements of the greatest diameter of the fruits.

(*e*) General notes of the leaf area, amount of shading, etc., of each fruit.

(*f*) Notes upon the behaviour of each apple during its life in common storage.

It is not intended at this stage to give any detailed account of the results so far accumulated in the course of taking these records, but merely to put on record the two very interesting facts that have already emerged and been referred to above. The more detailed data will be published as the points to which they relate are sufficiently well established. The whole of the data discussed in the present paper refer to the 1929 crop.

The Shape of Apples as Influenced by Their Position in the Fowler Cluster.

In taking the weekly measurements of the apples above mentioned it was noticed during the early summer that differences in shape were developing between the fruits growing from the terminal and lateral positions in the cluster. As early as July it was noticed that the terminal fruits of a cluster tended strongly to develop into somewhat egg shaped fruits. As compared with the lateral fruits of the same or other clusters, the terminal fruits were growing much more in length—length here being taken as the distance between the calyx and the stalk cavity—than were lateral fruits. Obviously there was thus a difference between the two sets of fruits in the way in which the apple flesh was being developed. This difference in shape became more marked as the season advanced. Towards the end of the growing season it was noticed that this tendency of the terminal fruits to assume an elongated form was continued at the cavity end, so that in many cases the cavity was completely filled with flesh and obliterated.

When gathered, the fruits which were developed from terminal blossoms of a cluster were of characteristic shape and appearance (Plate I). They were relatively elongated fruits, often tapering but slightly towards the calyx end and then rounding off very smoothly

to the calyx. A similar smoothness of rounding to the cavity was frequently evident. Sometimes the cavity was completely filled with tissue and, instead of a cavity, the fruit flesh extended for some little way down the fruit stalk. In these latter cases the fruits were distinctly egg shaped. In other cases where the cavity was not completely filled there was a more or less pronounced beak developed on one side of the fruit stalk. The fruit stalks of these terminal fruits were invariably shorter and stouter for the variety than the stalks of lateral fruits. In fact, quite often where the cavity was completely filled with tissue the fruits appeared to have no stalk at all. This apparent absence of a stalk was due, no doubt, to its being overgrown by the development of flesh in the apple cavity.

Most fruit growers will immediately recognise this description as corresponding to the " beaked " fruits which some varieties, such as Newton Wonder, always produce and which occur on other varieties to a less extent.

It was found that these beaked fruits were always developed from the terminal flower of the cluster.

At harvest time it is often difficult to be certain by an examination of the fruit while still attached to the tree whether it is developed from a lateral or a terminal flower, the old scars being frequently completely obliterated by the development of the fruit. However, by making a general survey in the Long Ashton plantations and in one or two large commercial orchards it was found that every " beaked " fruit examined was a terminal fruit.

Not all terminal fruits are beaked and there are considerable varietal differences shown in respect to the percentages of terminals which are " beaked." In Newton Wonder, for example, the terminal fruits were beaked almost without exception, whereas in Allington Pippin about 15-20% of the terminal fruits were without beaks.

In no case has a beaked fruit been found that was not a terminal fruit in the cluster. While it is true that some fruits that are terminal may be without beaks, it is equally true that they have all the other general characteristics of shape of the beaked type outlined above. Once having become familiar with the terminal fruits of a variety by observation of known terminal fruits, it is comparatively easy to pick out such fruits from a mixed sample of apples when they are off the trees.

At present our experience has been largely with the variety Allington Pippin but, as mentioned earlier, a certain amount of study has been given to the varieties Newton Wonder and King Edward VII. From trees of the latter variety at Long Ashton, it was found that

one apple in five was a terminal fruit. This, of course, is a very high percentage and means that a very large number of the terminal flowers must have matured into fruits. The prevalence of beaked fruits in the variety Newton Wonder is also evidence of a large proportion of terminal flowers in this variety "setting" and maturing into fruits. Other varieties examined do not seem to have many terminal fruits. There is, therefore, considerable varietal differences in the number of terminal fruits that a variety usually produces. The underlying factors in this varietal difference must sooner or later come under investigation. It would seem that growth conditions may have an influence upon this difference.

The Quality of Apples as Influenced by their Position in the Flower Cluster.

At harvest time approximately 40 terminal fruits and 160 lateral fruits of the variety Allington Pippin and of known history were available for storage. The present section deals only with a general comparison, and with the differences between these two sets of fruits considered as groups.

As the result of careful observation and tasting of both terminal and lateral fruits from the same trees and from different trees of the same variety under similar treatment, both where the fruits were kept in ordinary temperature and cold storage, it was found that they could be placed in two distinct quality groups. They divided themselves very clearly into (*a*) the terminal group of fruits and (*b*) the lateral group. It is suggested that the "maturity" of the fruits at picking time is probably one of the major factors responsible for the pronounced quality differences of these two sets of fruits found during the storage period; this factor is being further investigated.

Several examinations and tastings were carried out with the fruit in common storage. On December 20th the *terminal* fruits had a better appearance, were firmer and a brighter sample. The fruits of the terminal class were still quite turgid, whereas the lateral fruits on the whole were spongy to the touch and wrinkled and shrunk to a greater or less extent.

By tasting these fruits very pronounced differences were revealed between the two groups. The terminal fruits were much crisper in the flesh, but the flesh was distinctly watery. It lacked the "body" and "solidarity" that was a characteristic of the flesh of the lateral fruits. This difference in flesh texture between the two sets of fruits was quite apart from differences in flavour, aroma or sweetness.

A further consistent and striking difference between these two sets of fruit was that of sweetness. The lateral fruits were much sweeter than the terminals and were by far the better fruits from the consumer's point of view. They were sweeter and possessed higher aroma and a better flesh texture, in spite of the poorer general external appearance.

The question of acidity differences between the two groups is difficult to describe because of the masking effect of the sweetness in the lateral fruits. The terminal fruits appeared the more acid.

It is obviously impossible after such a short experience to describe these quality differences except in the above very general terms. The differences outlined, however, are clearly marked and consistent. They have been found in the fruits specially stored for the purpose of this study and in fruits that have been in storage for other purposes. It is the consistency and the obvious importance of these differences that have led to their report at this stage of the investigation.

Discussion.

The shape and general appearance of the terminal fruits suggest strongly that they continue to grow and develop much later in the season than do lateral fruits.

The differences in shape and quality between the two groups of fruit are interesting and important problems for investigation. Why two fruits, one a terminal and the other a lateral, growing upon the *same* flower truss upon the *same* spur and subtended by the *same* leaf area should be so different in both shape and quality is a problem of extreme importance where uniformity of sample and quality are important economic factors. Since the production of high grade dessert apples does demand uniformity, the differences here mentioned are of economic and practical importance.

An explanation must be sought by a closer study of the factors that determine the growth and maturity of the apple while it is still attached to the tree. The main differences in fruit quality are undoubtedly determined during the growing period, and it is to this part of the life cycle of the apple that more attention must be given if the differences here mentioned are to be elucidated.

The shape of the terminal fruits of a cluster suggests a different distribution of the growth centres in the apple during its early growing period. The difference is possibly an inevitable one due to position and vascular connections. This suggests that the terminal fruit is under somewhat different nutritional conditions during its development from a closely placed lateral fruit. The questions involved are clearly questions of growth, nutrition and anatomy, and are fundamental problems in plant physiology.

The terminal fruit of a cluster occupies a different position in tree economy from the laterals. It occupies on a spur or short shoot the position which corresponds to the terminal bud position of any other shoot on the tree. In a flowering shoot of the apple, pear, etc., the terminal bud position of such a shoot is occupied by the terminal flower and fruit and any further extension of such a shoot must come from a lateral bud, situated some way down on the cluster base. The tendency of terminal buds to assume the ascendency in shoot growth is too well-known to need emphasis at this point. Where a terminal flower develops, the fruit occupies this position of ascendency in shoot economy. In view of this pronounced tendency in all terminal positions of growth in the plant it is easy to assume that the terminal fruits of a cluster are growing under the same physiological urge.

It is along these and similar lines that further study is being made at Long Ashton and it is hoped that in due course a further contribution may be made to the more fundamental aspects of the observed differences in shape and quality between terminal and lateral fruits. In the meantime it is suggested that a given sample of fruits may be improved in uniformity of shape and quality if the terminal fruits are eliminated. Where thinning of the fruits upon the tree is practised, it would be possible to eliminate these fruits at this time. Each grower, however, must determine for himself whether the removal of all terminal fruits will represent too much thinning out. Pending further trials and experiments little definite practical advice can be offered.

In conclusion the writers would be glad to receive from interested persons any information regarding conditions where an abnormal number of terminal fruits, exhibiting the peculiar characters described in this paper are usually developed. There are grounds for thinking that certain growth and cultural conditions tend strongly to induce the "setting" and development of many terminal fruits. Such information that may be forthcoming undoubtedly will be of much value and assistance to the progress of these investigations.

PLATE I.

FIGURE 1. Showing the difference in shape between the terminal and lateral fruits from the same cluster. (Terminal left, lateral right.) Note in the terminal fruit the elongated shape and the thick fruit stalk as compared with the lateral fruit.

FIGURE 2. Showing the same two fruits as in Figure 1, but viewed from a different angle. Note the absence of stalk cavity in the terminal fruit and the developing "beak": also the elongated shape of the terminal fruit as compared with the lateral fruit.

Variety: Allington Pippin. Photographed September 14th, 1929.

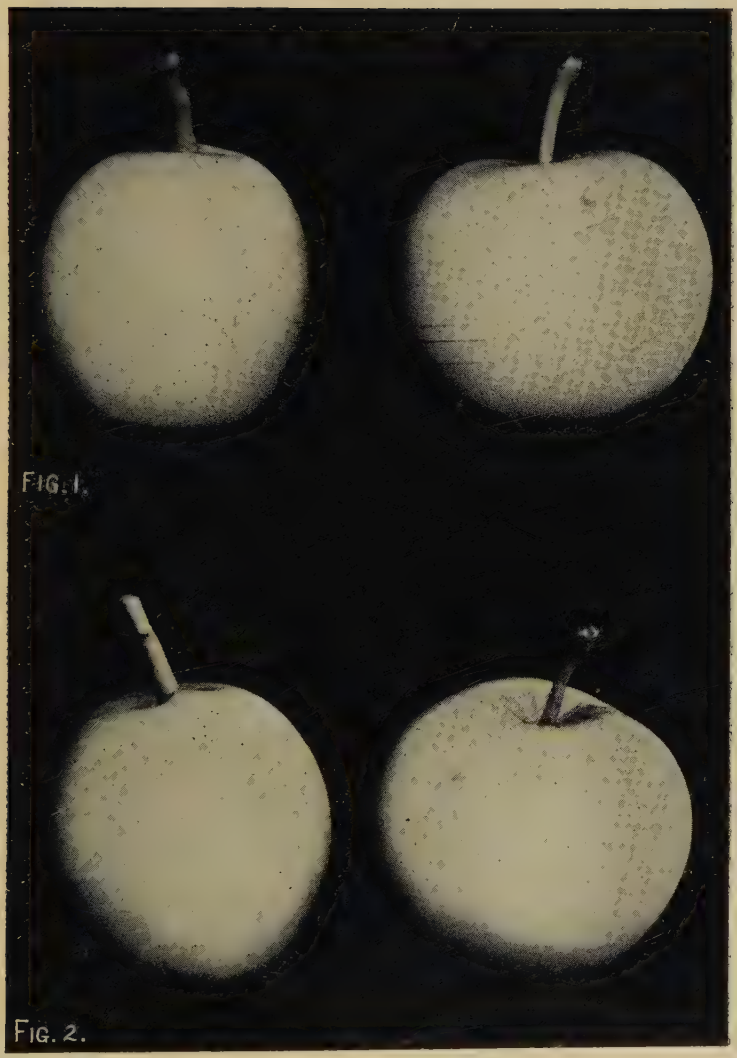


PLATE I.

INVESTIGATIONS ON CHLOROSIS OF FRUIT TREES.§

IV. THE CONTROL OF LIME-INDUCED CHLOROSIS IN THE FIELD.

By T. Wallace.

In papers I. and II. (19, 20) of the present series, results of chemical investigations on fruit trees in cases of lime-induced cholorosis were reported.

It was shown in those papers that the trees in question were all growing on soils containing high amounts of calcium carbonate, and that the foliage and stem portions of the terminal shoots of the chlorotic specimens, in all cases, showed definite and similar characteristics in the composition of the ash, etc., when compared with material from shoots bearing green leaves. Reference was also made to the fact that the particular chlorosis studied at these centres was associated with deficiency of iron, since the chlorotic foliage could be changed to a normal green by painting or spraying solutions of ferrous sulphate at appropriate strengths on the affected leaves.

Since the problem is of economic importance in certain of the large fruit areas in the country, experiments with a view to devising suitable methods of controlling the malady on a commercial scale were initiated at the centres previously reported on simultaneously with the chemical investigations.

This phase of the work has been in progress over four seasons and results have been obtained which it seems desirable to place on record at the present time.

The experiments have been confined, with one exception, to determining the value of sprays and of cover crops as means of effecting commercial control. The results reported show that while spraying methods do not appear to be suitable, cover crops seem to provide a suitable and cheap means of effecting a large measure of control over the condition.

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Historical.

As early as 1845, it was shown by Gris (5) that chlorosis in plants growing on calcareous soils in France was associated with iron deficiency, and that the condition could be remedied by treating the affected plants with iron salts. Since that time, numerous investigators have studied the problem in various parts of the world and in all cases, with comparatively rare exceptions, have found that the condition was associated with iron deficiency and was amenable to appropriate treatment with iron salts. Since extensive bibliographies of this work have been given by previous writers such as Leroux (10), reference will be made here to only a few of the contributions which deal with special points considered in this communication.

One of the most notable cases in which a lime-induced chlorosis has not been associated with iron deficiency is that which has been investigated at the Rhode Island Experiment Station, U.S.A. (2, 3), where it has been shown that the chlorosis is characterised by a deficiency in manganese and has been remedied by means of manganese compounds applied either to the foliage as sprays or to the soil incorporated in fertilisers.

In cases of lime-induced chlorosis associated with iron deficiency, the main problems relating to the control of the trouble have been to find methods of introducing the requisite amounts of iron into the affected plants without injuring them, and in effecting improvements of sufficient duration to render the methods of practical value. Among the chief methods tested have been the following* : application of iron salts to the soil ; spraying the foliage with solutions of iron salts at appropriate strengths ; painting cut surfaces of branches with iron solutions ; injecting solutions and crystals of salts into holes bored into branches as far as the wood.

In such experiments, it has been usual to find that ferrous sulphate is the most efficient compound to use. Applications direct to the soil have not generally been successful, though it is stated that chlorosis of Pineapples in Hawaii can be controlled by the *frequent* application of small doses of ferrous sulphate in this way (17), whilst Hendrickson (6) reports success on Pear trees as old as fifteen years from applying crystals of this salt near the roots of the trees by means of trenches and by holes bored in the soil with a soil auger, and watering the crystals applied to dissolve them. Trees treated in this way with 15 to 20 lbs. of ferrous sulphate per tree remained green for two years and showed only slight chlorosis in the third season.

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* Dusting with Marcasite has been recently suggested (17).

Considerable success has been obtained on some plants by spraying methods (8, 9), and, according to Johnson (8), iron salts are applied to the leaves of pineapples commercially on considerably over one half of the Hawaiian pineapple fields. It is to be noted, however, that all investigators agree that good effects from sprays are always temporary, and the operation needs either fairly, or very, frequent repetition. It has also been the general experience that the effects of the sprays are confined to the areas actually covered by them, and do not spread appreciably ; and often, because of this, the green colour developed takes the form of spotting.

Results from injections and dipping have also been found to be of a temporary character, and although these methods are regarded favourably by some workers (11), they are pronounced uncertain and unsafe by others (6), owing to the liability of injuring the plant by their use.

Three further methods by which lime-induced chlorosis associated with iron deficiency has been controlled or mitigated require mention, all being described by Gile and Carrero (4).

The first is by the application of very large doses of stable manure to the soil in cases of chlorosis of sugar cane and pineapples ; the second by incorporating in the soil large amounts of bulky organic materials such as tobacco stems, velvet beans, etc., where rice was the test plant ; and the third, again using the rice plant, by submerging the soil under water to a depth of three inches.

None of these three methods is suitable for application to fruit trees, as the first two, even if successful in controlling the chlorosis, would induce rank, undesirable growth, and produce fruits of inferior quality, whilst the third treatment would speedily lead to the death of the tree.

Whilst it has been demonstrated repeatedly that plants suffering from lime-induced chlorosis react to appropriate treatment with iron salts, the manner in which the plants develop " iron deficiency " is not understood. Opinions differ even on the point as to whether the iron content of chlorotic plants is less than that of comparable green plants, and it is not definitely established whether plants become chlorotic primarily because they are unable to absorb sufficient iron from the soil or whether the deficiency arises within the plant as the result of the iron becoming immobile from some internal cause (13).

It is difficult to ascertain from chemical analysis of green and chlorotic plants which of these views is correct and, whilst from

experiments on the application of ferrous sulphate to the soil, it appears true that plants do not obtain iron readily from chlorotic soils (6) it has been amply demonstrated in spraying, painting and injection experiments that iron salts are relatively immobile within chlorotic plants.

The manner in which calcium carbonate induces chlorosis has been studied by several workers but its action is not understood. In this connection, however, it has been shown that iron becomes less available to plants with increasing alkalinity of the nutrient medium (12) and that the form in which the iron is present in the soil (ferrous or ferric) may be of great importance (1).

Experimental.

As stated previously, the experiments described in this paper relate, with one exception (an injection experiment), to the use of sprays and cover crops as means of effecting a commercial control of lime-induced chlorosis of fruit trees. The experiments have usually been carried out on apple trees, though, in one case, plum trees were used and, in another, observations were made on pear trees.

The specific objectives of the spraying experiments were as follows :—

1. To determine the best strength of ferrous sulphate solution to use to effect control without causing spray damage, and to ascertain the duration of the beneficial effects of such sprays.
2. To determine whether control could be effected with aluminium sulphate solution, used at an appropriate strength.

The experiments with aluminium sulphate were included to see whether a sufficiently acid reaction could be imparted to the chlorotic tissues to render abnormally immobile iron within the plant more mobile.

The experiments with cover crops were initiated for two reasons. In the first place it was observed that on certain chlorotic areas, trees growing under grass conditions seemed much less susceptible to chlorosis than did others growing under arable conditions.

Secondly, good results on chlorotic plants had been obtained by Gile and Carrero (4) by incorporating heavy dressings of stable manure and various bulky organic residues into soils. The idea

was conceived that the beneficial effect might be produced by the increased content of carbon dioxide in the soil atmosphere resulting from such treatment lowering the pH value of the soil. If this were true, than a similar result might be expected by growing crops such as grass, clover, lucerne, etc., over the root systems of affected trees, since it appears from the investigations of several workers (14, 16, 18) that similar concentrations of carbon dioxide in the soil air result from growing such cover crops and from incorporating in the soil dressings of stable manure.

In connection with the possible effect of the carbon dioxide content of the soil air in lowering the pH value of the soil solution, it should be stated that whilst it has been demonstrated that by passing carbon dioxide into suspensions of soils giving alkaline reactions the pH values may be substantially lowered, it has not been established definitely that the increased concentration of CO_2 of the soil air, due to growing crops, effects any reduction in the pH value of the soil (7, 15).

The experimental difficulties of examining the point critically are great, and investigators who have failed to establish this latter effect of CO_2 in their experiments are not prepared to rule out the possibility of its occurring *in situ*, since it seems feasible that such effects may be produced very locally in proximity to absorbing root hairs (15).*

It has been stated that one injection experiment was carried out. It is not proposed to present this in detail, but it will suffice to record that the introduction of a small quantity of ferrous sulphate crystals into a branch bearing chlorotic foliage effected a temporary improvement similar to that described by various workers.

Experiments with Sprays.†

Spraying experiments were carried out at six centres during the seasons 1924 and 1925, and observations on the results of the treatments have been made at one of the centres over the period 9th June, 1924, to 4th July, 1927, in order to observe the duration of the initial effects produced.

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* See also. Truog. E. "How Plants Feed." Proc. : First Internat : Congress of Soil Science. Commiss : 3 & 4, P.630.

† Experiments described at Centres A, B, C, are in conjunction with Mr. A. D. Turner. Mr. C. E. T. Mann was also associated with these experiments during 1925.

The records of Centre D, for September 21st, 1925, were taken by Mr. N. Bagenal.

The data from the experiments are assembled in Table I. The soils at the centres used, with the exception of Centre F, have all been described in Paper I. of this series, and by referring to the Geological Formations shown in the above table and those given in Table I, Paper I, it is possible to identify the centres. The soil at Centre F. is a calcareous boulder clay, overlying a heavy calcareous Lias clay. The percentages of calcium carbonate in the surface and subsoil are as follows : surface soil, 7.02 per cent. ; subsoil, 9in. to 18in., 12.66 per cent. ; subsoil, 18in. to 30in., 16.94 per cent.

Preliminary trials were carried out with ferrous sulphate at Centre A in 1924 to obtain information on the strength of spray solutions in relation to efficiency and damage. It was found that a 1.0 per cent. solution was more effective than one of 0.5 per cent. strength, and the observation was made that the addition of a suitable spreader was necessary to wet the foliage adequately.

The main trials were carried out in 1925, and in these ferrous sulphate and aluminium sulphate were tested, in all cases a spreader (an organic base caseinate) being added at 0.1 per cent. strength. By the aid of this spreader very thorough wetting of the foliage was obtained in all cases.

The salient points shown by the data in Table I are as follows :—

Ferrous Sulphate.

1. Ferrous sulphate used at 1 per cent. strength was in some cases very effective in controlling the chlorotic condition during the season of application, *e.g.*, Centre C, variety Monarch ; in others the control effects were variable, *e.g.*, Centre C, variety Newton ; and in others good effects were practically negligible, *e.g.*, Centre F.

2. 1.0 per cent. strength was more effective than 0.5 per cent. or 0.25 per cent. Results with 0.25 per cent. at Centre D were negligible.

3. Where the duration of effects was observed at Centre A, it was noted that these were only temporary. In the second and third seasons after spraying, all beneficial effects had usually disappeared completely.

4. Damage to the foliage from 1.0 per cent. solution was sometimes very serious, especially where the chlorosis was in an advanced stage. Note damage at Centre F.

TABLE I. *Spraying Trials.*

Centre	Geological Formation	Particulars of Trees.	Particulars of Sprays, etc.	Observations on Chlorosis.	Damage from Sprays.
A.	Dolomitic Conglomerate	Apple—var.: Duke of Devonshire; age 11 years in 1924.	9/6/24. Some branches sprayed with $FeSO_4$ at 0.5% and 1.0% strength.	9/6/24. Sprayed branches, Chlorosis bad. 23/9/24. Sprayed foliage showed some improvement. 1.0% $FeSO_4$ more effective than 0.5%.	
			12/6/25. Whole tree sprayed with 1.0% $FeSO_4$ + organic casein spreader.	12/6/25. Chlorosis bad. Very little residual effect from previous spraying. 4/9/25. Chlorosis slight to medium. One branch bad. Spray effective some branches 4/7/27. Chlorosis bad. Previous effects of sprays not retained.	Severe, usually as burning in spots.
		Apple—var.: King of the Pippins; age as above.	9/6/24. Do. 12/6/25. Do.	9/6/24. Chlorosis bad. 23/9 24. Some improvement. 12/6/25. Chlorosis bad.	
				4/9/25. Chlorosis medium to bad. Slight improvement from spraying. 4/7/27. Chlorosis bad.	Severe, as marginal scorching.
		Apple—var.: Rich's Favourite; age as above.	12/6/25. Whole tree sprayed with 1.0+ $FeSO_4$ + organic casein spreader.	12/6/25. Chlorosis very bad. 4/9/25. Chlorosis slight to medium, some branches; others practically no effect from spray. 4/7/27. Chlorosis very bad.	Slight except on most chlorotic branches where severe.
		Apple—var.: Wellington; age as above.	Do.	12/6/25. Chlorosis very bad. 4/9/25. Chlorosis very slight. Only a few leaves chlorotic. Spray very effective. 4/7/27. Chlorosis medium. One branch bad. Some improvement still maintained.	Slight.
		Apple—var.: Peasgood Nonsuch; age as above.	12/6/25. Whole tree sprayed with 1.0% $Al_2(SO_4)_3$ + organic casein spreader.	12/6/25. Chlorosis bad. 4/9/25. Chlorosis bad. No visible effect from spray.	Very slight.

TABLE I.—*continued.*

Centre	Geological Formation	Particulars of Trees.	Particulars of Sprays, etc.	Observations on Chlorosis.	Damage from Sprays.
B.	Inferior Oolite.	Apple—var.: King's Acre Pippin; age 3 years.	12/6/25. Sprayed with 1.0% $FeSO_4$ + organic casein spreader.	12/6/25. Chlorosis bad. 4/9/25. Chlorosis medium. Most chlorotic foliage much green spotting. definite improvement.	Slight.
		Do.	12/6/25. Do.	12/6/25. Chlorosis very bad. 4/9/25. Chlorosis bad. Chlorotic leaves show green patches and spots. Slight improvement.	Slight.
		Apple—Four trees, var.: Lane's Prince Albert; age 3 years.	12/6/25. Do.	12/6/25. Chlorosis bad all trees. 4/9/25. Chlorosis only very slight all trees.	Slight spotting.
		Apple—Five trees—var.: Lane's Prince Albert; age 3 years.	No spray. Controls to Lane's above.	12/6/25. Chlorosis bad all trees. 4/9/25. Chlorosis slight all trees. Show much natural recovery. Definitely more chlorotic than $FeSO_4$ sprayed trees.	
		Do.	12/6/25. Sprayed with 1.0% $Al_2(SO_4)_3$ + organic casein spreader.	12/6/25. Chlorosis bad all trees. 4/9/25. Chlorosis medium. More severe than controls. No visible improvement from spray.	Negligible.
C.	Lower Lias.	Apple—var.: Monarch; standards in nursery; age 3 years. Ten trees	12/6/25. Sprayed with 1.0% $FeSO_4$+ organic casein spreader.	12/6/25. Chlorosis bad. 4/9/25. Chlorosis practically nil all trees. Spray very effective.	Negligible.
		Do.	No spray. Control for above.	12/6/25. Chlorosis variable. Mostly bad. On whole slightly better than sprayed trees. 4/9/25. 6 trees Chlorosis bad.; 2 trees Chlorosis medium; 2 trees Chlorosis slight.	
		Apple—var.: Newton Wonder; standards in nursery. Ten trees.	12/6/25. Sprayed with 1.0% $FeSO_4$+ organic casein spreader.	12/6/25. Chlorosis bad. 4/9/25. 1 tree Chlorosis bad; 2 trees Chlorosis medium; 1 tree Chlorosis slight to medium; 4 trees Chlorosis slight; 2 trees Chlorosis slight.	

TABLE I.—*continued.*

Centre	Geological Formation	Particulars of Trees.	Particulars of Sprays, etc.	Observations on Chlorosis.	Damage from Sprays.
D.	Chalk.	Apple—var. : Worcester, Cox's Orange Pippin.	12/6/25. Preliminary trials with $FeSO_4$ at 1.0%, 0.5%, 0.25% strengths to ascertain damage.	12/6/25. Chlorosis bad. Trees in very poor condition.	?/6/25. 1%, trees practically defoliated. 0.5%, serious defoliation. 0.25%, no defoliation.
		Apple—3 trees—var. : Cox's Orange Pippin ; age 7 years.	?/6/25. 0.25% $FeSO_4$ + organic casein spreader.	12/6/25. Chlorosis bad all trees. 21/9/25. Chlorosis bad. No visible effect.	
		Do.	?/6/25. 0.25% $Al_2(SO_4)_3$ + organic casein spreader.	12/6/25. Chlorosis bad all trees. 21/7/25. Chlorosis bad. No effect.	
		Apple—3 trees—var. : Worcester Pearmain ; age 7 years.	3/6/25. 0.25% $FeSO_4$ + organic casein spreader.	12/6/25. Chlorosis bad all trees. 21/9/25. Chlorosis bad. No effect.	
		Do.	?/6/25. 0.25% $Al_2(SO_4)_3$	12/6/25. Chlorosis bad all trees. 21/9/25. Chlorosis bad. No effect.	
E.	Keuper Marl.	Apple—3 trees—var. : Lord Grosvenor ; age 10 years.	?/6/25. 1.0% $FeSO_4$ + organic casein spreader.	?/6/25. Chlorosis bad all trees. 21/9/25. Chlorosis medium to slight. Spray had produced visible effects.	Slight.
		Apple—3 trees—var. : Lord Grosvenor ; age 10 years.	?/6/25. 1.0% $FeSO_4$ + organic casein spreader.	?/6/25. Chlorosis bad all trees. 21/9/25. Chlorosis bad. Spray no effect.	Negligible.
F.	Drift over Lower Lias.	Plum—var. : Purple Per-Shore ; age 16 years.	17/5/25. 1.0% $FeSO_4$ + Organic casein spreader.	17/5/25. Chlorosis bad. 11/5/27. Chlorosis bad.	25/5/25. Foliage and young fruits severe burning effects. Leaves crippled.

Aluminium Sulphate.

6. This material did not produce beneficial effects in any cases.

7. Damage from its use was less than from ferrous sulphate used at equal strength.

Experiments with Cover Crops.

Experiments on the use of permanent cover crops have been carried out at three Centres, viz. D. E. F.

Those at D. and E. have been on a fairly large scale and have extended over several seasons—D. 1925 to 1928 inclusive, E. 1924 to 1928 inclusive, whilst at F. only a small number of trees have been used and the observations have extended over two seasons only.

At Centre D it has also been possible to make a general observation for one season on the effect of a cover crop on approximately seven acres.

Centre D.—(In conjunction with N. Bagenal.)

The trees used in this experiment were bush apple trees of the varieties Cox's Orange Pippin and Worcester Pearmain. They had been planted about seven years when first seen in June, 1925.* Up to that time they had been growing under conditions of clean cultivation and had gradually developed very severe chlorosis. In 1925, previous to the experiment, practically every tree was markedly chlorotic, there being only occasional trees which were retaining any considerable proportion of green foliage.

For the purposes of the experiment on cover crop effects, a portion of the field was divided into plots which were located side by side and separated from each other by buffer rows.

The details of the trees in each plot, together with the cover crop treatments which have been given, are shown below. The plots are listed in the order of occurrence in the field.

Plot I. Tumbledown grass, run with ducks from August, 1925.
Cox's Orange Pippin : 20 trees in 3 rows.
Worcester Pearmain : 10 trees in 1 row.
Total trees, 30.

Buffer Row a. As Plot I, one side and as Plot II the other.
Cox's Orange Pippin : 21 trees in 1 row.
Total trees, 21.

* The trees in Plot V were one year younger.

Plot II. Clean cultivation until August, 1926; since then tumbledown grass + wild white clover.
Cox's Orange Pippin: 27 trees in 1 row.
Worcester Pearmain: 33 trees in 1 row.
Total trees, 60.

Buffer Row b. As Plot II one side and as Plot III the other.
Cox's Orange Pippin; 38 trees in 1 row.
Total trees, 38.

Plot III. Lucerne from July, 1925. Crop cut and left on ground.
Cox's Orange Pippin: 148 trees in 3 rows.

Buffer Row c. As Plot III one side and as Plot IV the other.
Worcester Pearmain: 56 trees in 1 row.
Total trees, 56.

Plot IV. Tumbledown grass and wild white clover from August, 1925.
Cox's Orange Pippin: 451 trees in 8 rows.
Worcester Pearmain: 114 trees in 2 rows.
Total trees, 565.

Buffer Row d. As Plot IV one side, clean cultivation the other.
Cox's Orange Pippin: 51 trees in 1 row.
Total trees, 51.

Plot V. Clean cultivated until August, 1926; since then tumbledown grass and wild white clover.
Cox's Orange Pippin: 108 trees in 2 rows.
Worcester Pearmain: 55 trees in 1 row.
Total trees, 163.

The following notes, taken on the dates of recording the intensity of chlorosis in the season 1926, 1927, 1928, show the condition of the cover crops in those seasons and refer to certain points of management of these which affected the occurrence of chlorosis.

July, 1926.

Plot I. was under tumbledown grass and was stocked with ducks. The grass had made a fairly good cover and consisted chiefly of *Poa annua*. There were a few bare patches, chiefly around the duck house.

Buffer a. Cover was as for Plot I on one side and as for Plot II on the other.

Plot II. The soil was cultivated and practically free from weeds.

Buffer b. One side was as for Plot and the other as for Plot III.

Plot III. The lucerne had made a fairly good cover. It had been cut once and the hay left to rot.

Buffer c. One side was as for Plot III and the other as for Plot IV.

Plot IV. The cover of grass and clover was rather thin, the growth of the clover being patchy.

Buffer d. One side was as for Plot IV and the other as for Plot V.

Plot V. The area was cultivated and practically free from weeds.

August 5th, 1927.

The area from Plot I to Buffer *d* was all stocked with ducks at the rate of 160 birds per acre. Houses to accommodate them had been erected on the plots. Small areas, usually a few square yards, around the houses, were generally worn bare by the ducks and on all such areas a few trees showed marked chlorosis.

Plot I. The cover was very poor, many areas having been worn bare by the ducks. Chlorosis on the plot occurred on these areas.

Plot II. The cover was fairly thin, the clover being only poorly developed.

Plot III. The lucerne had made very strong growth and had provided an excellent cover.

Plot IV. There was a good cover of clover.

Plot V. The cover was fairly thin and the clover not well developed.

The herbage of the Buffers on this date showed the characters of the plots on either side of them.

July 25th, 1928.

The cover was good over the whole area of the plots, with the exception of some worn patches on Plot I and of small areas around the duck houses.

On this occasion, it was evident that wherever the cover afforded by any of the cover crops was thick, chlorosis (apart from capsid damaged trees—see below) was negligible.

The method of marking the intensity of chlorosis on each occasion was as follows :—

Nil : Tree free from chlorosis.

Trace : A small proportion of the foliage slightly chlorotic.

Slight : A fair proportion of chlorotic foliage. The chlorotic condition easily observable but not serious.

Medium: The foliage was generally more or less chlorotic but there was a certain proportion of green leaves and shoot growth was not visibly affected.

Bad: Chlorosis severe, shoot growth restricted and in some cases branches dying back.

Where the condition of a tree was judged to be intermediate between two categories, a plus or minus sign was added to the marking recorded to show whether the condition tended to be less or more severe than the category marked.

For the purpose of presenting the results in this paper, numerical values have been assigned as follows :—

Trace	$\frac{1}{2}$
Slight	1
Slight to Medium	$1\frac{1}{2}$
Medium	2
Medium to Bad	$2\frac{1}{2}$
Bad	3

Capsid damage was very severe on the trees in 1927 and 1928, and especially so on Cox's Orange Pippin. This rendered recording very difficult in those seasons, since the pest-affected trees developed late terminal growths of a semi-chlorotic character and it appeared on recording that many trees marked as chlorotic—generally in the category " trace "—would have been marked as nil but for such effects. In 1928, a large number of trees bearing this type of foliage were marked " trace ? " and have been calculated as $\frac{1}{4}$.

The markings in these seasons are thus doubtless on the high side. Terminals injured by scab and mildew also produced late growths of this type.

The results calculated by the above method have been summarised in Table II for the seasons 1926-1928.

TABLE II. *Showing Markings for Chlorosis per Tree.*

Plot No.	No. of Trees recorded.	1926.	1927.	1928.
Plot I ..	30	0.60	**1.35**	0.33
Buffer a ..	21	*1.52*	0.66	0.31
Plott II ..	60	**1.64**	0.23	0.11
Buffer b ..	38	*1.64*	0.82	0.14
Plot III ..	148	0.52	0.65	0.12
Buffer c. ..	56	0.31	0.72	0.10
Plot IV ..	565	0.74	0.75	0.17
Buffer d ..	51	*1.07*	0.65	0.12
Plot V ..	163	**1.75**	0.55	0.10

There is one point which requires mention in connection with the method of presentation of the data. This is that the values for the two varieties have not been presented separately in the Table. The reasons for this are as follows :—

It is not intended that the values should be regarded as being strictly quantitative. The severity of the chlorosis on the two varieties prior to cover crop treatments was very similar, and on the large majority of trees would have been classed as " Medium " (numerical value 2). The final results for the varieties were also very similar, as can be seen by comparing the results for the Buffer Rows b, c and d, d being comprised entirely of Worcester and b and c entirely of Cox's Orange Pippin. The only significant differences between the varieties which were observed occurred in 1927, when two rows of Worcester—Buffer Row c and a row in Plot IV—showed more severe chlorosis than any row of Cox's Orange Pippin. The difference, however, was easily accounted for, since it was noted that the chlorotic foliage of the Worcester trees in question was borne on secondary growths of terminals and was thus of abnormal occurrence.

The salient features to be noted in the data are as follows :—

In 1926, after one season of treatment, the intensity of the chlorosis on all the cover crop plots was markedly less than on the cultivated Plots II and V and on the Buffer Rows a, b and d receiving cultivation on one side of the tree rows.

The grassing down treatments given to Plots II and V from the August of 1926 reduced the severity of the chlorosis on those plots and on the adjoining buffer rows previously under half cultivation during 1927.

The effects of intensive stocking with ducks in 1927 on Plot I, which led to the partial destruction of the cover crop, is shown in the increased figure recorded for chlorosis on that plot.

In 1928, on all plots with the exception of Plot I and Buffer Row a, the amount of chlorosis was practically negligible. The slightly higher values on those two plots were noted as due to incomplete covering of the surface by the cover crop.

The figures show conclusively the effect of the various cover crops in controlling the chlorotic condition on the plots.

It should be added that even in 1927, when the values on the area from Buffer Row a to Plot V are shown as usually greater than 0.5, reaching a value of 0.82 on Buffer Row b, an attempt was made to obtain a sample of terminal shoots bearing wholly chlorotic leaves for analytical purposes, but it was found impossible to do so.

After noting the good effects following the establishment of the cover crops on the experimental area, the whole of the area of the

plantation outside the plots was left uncultivated during 1927 and white clover sown over it. Previous to this, chlorosis was general over this area and in August, 1928, after two seasons of this tumble-down grass plus clover treatment, the only trees on the area remaining chlorotic were a few pear trees, which appear to be highly susceptible to the trouble.

*Centre E.**

The trees at this centre are bush apple trees, the varieties being Lane's Prince Albert, Lord Derby, Rev. Wilks and Red Victoria with a few odd trees of the variety Crimson Bramley. The block had been planted for five seasons when first inspected by the writer in 1924. At the time, chlorosis was distributed more or less generally over the whole area though there were patches where the trouble was extremely severe and others where it was relatively slight. As the result of differences due to variation in intensity of chlorosis, some of the less affected trees of the variety Lane's Prince Albert measured 6 feet in height, whilst the most severely affected were less than 3 feet high and had made no progress since planting.

The whole of the area subsequently used as the experimental area was allowed to tumble down to grass and weeds from July, 1924. The trees were not marked individually previous to this, only a general note being made on them, since in the first place it was proposed to observe only very large effects, such as the difference between the possibility or impossibility of growing trees on the area under the two cultural conditions, as it was recognised that under cultivation, the trees were rapidly declining and, in many cases, would soon be quite useless.

During 1925, the area was covered with a growth of grass consisting almost entirely of *Poa annua*. The effect of this treatment was remarkable. Many of the trees which had previously been very severely chlorotic and in a stagnant condition produced terminal shoots from 1 foot to 2 feet in length and bore normally green foliage.

The individual trees of a single row containing sixteen trees, running through the worst area, were recorded, using the method described for the experiment at Centre D, and it was found that the average marking was less than a trace, the highest value being slight +.

Since then the plot has been used to study three points : the permanency of the grass effect, the rate of development of the

* Mr. C. Taborn has applied the sulphate of ammonia at this centre and assisted with the recording in the seasons 1926, 1927 and 1928.

Mr. C. E. T. Mann was responsible for the 1926 records.

chlorotic condition following the resumption of cultivation, and the management of the " grassed " trees to prevent nitrogen starvation.

Cultivation was resumed in August, 1925, on the row recorded in that year, and from August, 1926, four more rows adjoining it were put under cultivation. Two further rows were added to the cultivated section from winter 1927-28.

During 1926, a portion of the grassed area was dressed with sulphate of ammonia at 2 cwts. per acre and in 1927 and 1928 only a portion of this area received sulphate of ammonia, at the rate of 3 cwts. per acre, a larger area being left in these years with the treatment " grass only." In the autumn of 1927 the trees on the plots were thinned, alternate trees being removed.

The method of recording the degree of chlorosis was the same as described at Centre D, and the records have been assigned numerical values in the same way. Here again the records have not been analysed separately for the different varieties, since the differences between varieties have been very small in comparison with the differences due to cultivation and grass treatments, and the various plots have contained the different varieties in approximately equal proportions.

TABLE III.—*Showing Chlorosis Marking—as Averages per Tree.*

Season	Cultural Treatment, etc.	No. of Trees recorded.	Chlorosis marking as average per tree.
1925	1 year under grass	16	0.33
1926	1 year cultivated after 1 year grass	16	1.00
	2 years grass	64	0.06
	2 years grass + sulphate of ammonia at 2 cwts. per acre second year	128	0.14
1927	2 years cultivated after 1 year grass	16	1.00
	1 year cultivated after 2 years grass	64	0.23
	2 years grass, then 1 year half cultivation, half grass (buffer row)	16	0.17
	3 years grass (48 received sulphate of ammonia 1926)	96	0.03
	3 years grass + sulphate of ammonia 1926,1927	48	0.19
1928	3 years cultivated after 1 year grass	8	1.31
	2 years cultivated after 2 years grass ..	32	0.60
	1 year cultivated after 1 year half cultivated, following 2 years grass	8	0.22
	1 year cultivated after 3 years grass	14	0.07
	4 years grass (received sulphate of ammonia 1926)	32	0.07
	4 years grass + sulphate of ammonia 1926, 1927, 1928	24	0.01

The growth of the cover crop at this centre has not been very vigorous, since it has been composed throughout the experiment chiefly of *Poa annua* and has tended to " burn " badly during late July and August. The growth of the plot receiving sulphate of ammonia during all three seasons was stronger than on the remainder of the grassed area.

The results are presented in Table III in an appropriate form to show the important points which have emerged.

The most striking point of the data is, of course, the very large difference between the values for the cultivated and grassed areas and it is obvious that at this centre the cover crop has again exercised a considerable measure of control over the chlorosis.

The second feature of interest is the rate of return of chlorosis following the resumption of cultivation after varying periods of grass treatment, this point being clearly shown in the data for 1928.

Centre F.

The trees observed at this centre are plum trees of the variety Purple Pershore, stated to be sixteen or seventeen years of age in 1926.

Chlorosis had been developing gradually for a few seasons previous to the above year and growth, which had been good in the early stages, had gradually fallen off.

In August, 1926, all the trees concerned, about twelve in all, were markedly chlorotic. An attempt to control the chlorosis on a few branches with 1.0 per cent. sulphate of iron in May, 1925, resulted in serious foliage damage and the trees again showed severe chlorosis during the season.

The area was sown down to rye grass in the spring of 1928 and an excellent cover was obtained during that season.

The condition of the trees was observed on July 20th, and on that occasion the amount of chlorosis present was negligible.

Discussion.

The results described in the experiments with sprays show that the method does not appear to be a suitable one for controlling chlorosis of apple and plum trees on a commercial scale.

Beneficial effects from ferrous sulphate, which is generally recognised as the most efficient material for the purpose, are uncertain, and considerable damage to the foliage occurs from its use in many cases.

The experiments with cover crops show that this method is likely to prove of great value in controlling cases of lime-induced chlorosis in this country. The experiment at Centre D can be regarded as having been carried out under extreme conditions of soil, since the latter is derived from pure chalk rock, the surface soil containing 60.0 per cent. of calcium carbonate and the subsoil consisting of chalk rubble.

The method as one for use on fruit trees such as the apple and pear has the advantage over all methods previously described in that it is simple, involves no extra trouble or expense, requires no special skill to carry out, and does not affect the fruit quality adversely.

The only point which requires mention regarding its use is that trees grown under such conditions soon become starved due to lack of nitrogen, and it will be necessary in many cases to apply fairly heavy dressings of quick-acting nitrogenous manures such as nitrate of soda or sulphate of ammonia at rates possibly as heavy as 5 cwts. per acre each year. On theoretical grounds sulphate of ammonia will probably be more suitable than nitrate of soda for this purpose.

The reasons for testing the cover crop method have been stated previously, but the mechanism of the action has not been investigated. It should be mentioned, however, that it has been shown in a previous paper (19) that chlorotic leaves rendered green by the use of either ferrous sulphate or cover crops show the same change in relationship in the ratio of Ca K in passing from the chlorotic to the green condition, which suggests that the cover crop, when effective, influences the functioning of iron within the tree, either by increasing the intake of iron or by rendering active some portion of the iron already contained in the tissues.

Conclusions.

1. The action of ferrous sulphate sprays in controlling lime-induced chlorosis of fruit trees associated with iron deficiency, is uncertain ; such sprays sometimes produce good results and in other cases the beneficial effects are very small. Considerable damage may result from their use.

2. Aluminium sulphate used as a spray does not exercise any controlling effect over lime-induced chlorosis of fruit trees.

3. Considerable control of lime-induced chlorosis of fruit trees may be obtained by growing permanent cover crops over the root systems of the affected trees. The method appears to be of considerable commercial value.

Summary.

1. A brief account is given of the utility and limitations of methods previously used for controlling lime-induced chlorosis in various plants.

2. Reference is made to the views of investigators on the causes of lime-induced chlorosis and the possible mechanisms of the various ameliorative measures proposed.

3. Experiments on the use of sprays containing ferrous sulphate and aluminium sulphate and the effects of cover crops as means of controlling lime-induced chlorosis of fruit trees associated with iron deficiency are described. It is shown that while spraying methods are unsuited for commercial purposes on fruit trees, the use of cover crops appears to offer a simple and effective means of controlling the trouble.

References.

(1) Brewer, P. H. and Carr, R. H. "Fertility of a Soil as Related to the Forms of its Iron and Manganese." *Soil Sc.*, Vol. 23, pp. 165-173 (1927).

(2) Gilbert, B. E., McLean, F. T. and Hardin, L. J. "The Relation of Manganese and Iron to a Lime-induced Chlorosis." *Soil Sc.*, Vol. 22, pp. 437-446 (1926).

(3) Gilbert, B. E. and McLean, F. T. "A 'Deficiency Disease': The Lack of Available Manganese in a Lime-induced Chlorosis." *Soil Sc.*, Vol. 26, pp. 27-32 (1928).

(4) Gile, P. L. and Carrero, J. O. "The Cause of Lime-induced Chlorosis and Availability of Iron in the Soil." *J. Agric. Res.*, Vol. 20, pp. 33-61 (1920).

(5) Gris, E. *Compt Rendu. Acad, Sci* (Paris), t. 21, No. 25, pp. 1386-1387 (1845).

(6) Hendrickson, A. H. "A Chlorotic Condition of Pears." *Proc. Amer. Soc. Hort. Sc.*, pp. 87-90 (1924).

(7) Hoagland, D. R. and Sharp, L. T. "Relation of Carbon Dioxide to Soil Reaction as measured by the Hydrogen Electrode." *J. Agric. Res.*, Vol. 12, pp. 139-148 (1918).

(8) Johnson, M. O. *Hawaii Agric. Expt. Stn. Bull.* 52 (1924). Bot. *Abs.* Vol. XIV, No. 1., p. 95 (1925).

(9) Korstian, F. K., Hartley, C., Walls, L. F. and Hahn, G. H. "A Chlorosis of Conifers Corrected by Spraying with Ferrous Sulphate." *J. Agric. Res.*, Vol. 21, pp. 153-169 (1921).

(10) Leroux, L. "La Chlorose des Plantes." *Rev. Gen. des Sciences*, Vol. XXXVI, pp. 418-420 (1925).

(11) Lipman, C. B. and Gordon, A. "Further Studies on New Methods in the Physiology and Pathology of Plants." *J. Gen. Phys.*, Vol. 7, p. 615-623 (1925); *Bot. Abs.*, Vol. 15, No. 3, p. 452 (1926).

(12) McCall, A. G. and Haag, J. R. "The Relation of the Hydrogen Ion Concentration of Nutrient Solutions to Growth and Chlorosis of Wheat Plants." *Soil Sc.*, Vol. 12, pp. 69-77 (1921).

(13) Milad, Y. "The Distribution of Iron in Chlorotic Pear Tress." *Proc. Amer. Soc. Hort. Sc.*, pp. 93-98 (1924).

(14) Parker, F. W. "Carbon Dioxide Production of Plant Roots as a Factor in the Feeding Power Plants." *Soil Sc.*, Vol. 17, pp. 229-247 (1924).

(15) Pierre, W. H. "The Hydrogen Ion Concentration of Soils as affected by Carbonic Acid and the Soil-Water Ratio, and the Nature of Soil Acidity as revealed by these Studies." *Soil Sc.*, Vol. 20, pp. 285-305 (1925).

(16) Russell, E. J. and Appleyard, A. "The Atmosphere of the Soil: its Composition and the Causes of Variation." *J. Agr. Sc.*, Vol. 7, pp. 1-48 (1915).

(17) Tropical Agriculture. *Chem. Notes*, p. 686, Oct., 1928. (Refs. to some results of M. O. Johnson).

(18) Turpin, H. W. "The Carbon Dioxide of the Soil Air." Cornell Memoir 32 (1920).

(19) Wallace, T. and Mann, C. E. T. "Investigations on Chlorosis of Fruit Trees—I." *J. Pomol. and Hort. Sc.*, Vol. V., pp. 115-123 (1926).

(20) Wallace, T. "Investigations on Chlorosis of Fruit Trees—II." *Ibid.*, Vol. VII (1928).

FURTHER OBSERVATIONS ON A PYRETHRUM SPRAY FLUID.

By F. Tutin.

In the Annual Report of this Research Station for 1928, the present author gave an account of the preparation of a *Pyrethrum* Spray Fluid which, on trial against a variety of insects, appeared to give very satisfactory results.

This spray fluid, as adapted for use in the field, was prepared in the following manner. The coarsely ground *Pyrethrum* flowers were extracted with light petroleum and the residue obtained on removal of the petroleum, which represented the crude pyrethrins, was dissolved in Rape oil. In order to effect the emulsification of this mixture some of the sulphonated oil, Agral W.B., was added to it, the resulting mixture was added to the desired volume of water, the necessary amount of alkali subsequently added, and the mixture stirred. For example, the material dissolved by petroleum from 100 lbs. of the dried flowers was dissolved in 15 gallons of Rape oil and 5 gallons of Agral W.B. added. When required for use, 2 gallons of this mixture were added to 98 gallons of water, two pints of 40% sodium hydroxide then introduced, and the mixture stirred. When working with a somewhat "hard" water it was found that a rather better emulsion was obtained if the mixture was prepared in the first instance with the use of only 20 gallons of the water, the remainder being added immediately after the alkali had been thoroughly stirred in.

The spray mixture so prepared represents a concentration of approximately 1% of the original flowers and has been found, by fairly extensive field trials, to give very encouraging results for the control of the Raspberry or Logan Beetle.§

Several commercial preparations containing the active principles of *Pyrethrum* flowers dissolved in petroleum products have been used for the destruction of House Flies, but there are obvious objections to the employment of such preparations for the control of insect pests on plants, notably that of the damage caused to the more delicate vegetation by the solvent employed. It was largely for this reason that the present author replaced the petroleum

§This Report, p. 115.

by Rape oil as a solvent. It may be mentioned, however, that in the trials conducted during 1929 it has been found that Cotton Seed Oil is equally, if not more, satisfactory and is, moreover, a somewhat cheaper product.

It is well known that the pyrethrins readily undergo hydrolysis, thereby losing their toxicity when exposed to the action of alkalis. It was for this reason that Agral W.B. was employed as an emulsifier since, with this agent, the alkali was only introduced immediately before use. Under these conditions it was found that the activity of the mixture was kept for a number of days and that the product, when applied to plants, did not cause the slightest damage to even the most delicate portions of vegetation. It was hoped that the Agral W.B. would cause no diminution of the toxicity of the mixture, but it has been found that it does cause slow change. No loss of activity could be detected after an interval of two months but, after keeping the fatty oil solution of the crude pyrethrins and Agral W.B. for 14 months, the mixture appeared to possess only about half of its original insecticidal power. It is evident, therefore, that the ideal method of emulsification has not yet been found.

1929 Trials.

In spite of these imperfections of the *Pyrethrum* spray fluid in its present form as described, it has again yielded very encouraging results in further trials conducted in 1929. In addition to those conducted against the Raspberry or Logan Beetle by Dr. Walton (*loc. cit.*) it has been used against the Willow Beetle, *Phyllodecta vulgatissima*, *Aphis* sp. and the Red Spider, *Oligonychus ulmi*, with apparently good effect. The experiment against the Willow Beetle, however, cannot be regarded as conclusive owing to the lack of efficiently planned " controls." In the case of Red Spider a number of mature apple trees heavily infested with this pest were sprayed on the 12th of June with the *Pyrethrum* mixture and the control of the pest appeared to be complete, whilst no damage to foliage resulted. For comparison adjacent trees, also heavily infested, were treated with lime sulphur at a concentration of 1 in 30: this likewise controlled the pest, but caused considerable " scorching " of the leaves of the less hardy varieties.

The total absence of damage to vegetation resulting from the use of the *Pyrethrum* spray mixture is, of course, a great asset. In this connection it may be noted that in one experiment, when spraying against the Raspberry Beetle, eight times the correct amount of caustic alkali was used, by a mistake, in mixing the spray. Even with this faulty mixture the efficiency of the spray did not seem to be impaired and only an entirely negligible amount of damage was done to the plants.

Since some workers have been conducting experiments with aqueous and alcoholic extract of *Pyrethrum* flowers, the constituents of the latter which are insoluble in light petroleum have been further examined with respect to their insecticidal powers. The material which was dissolved by ether after the flowers had been extracted with petroleum was, at first, found to possess distinct insecticidal activity. When, however, it had been re-extracted with petroleum it was found to be inert, as stated in the previous paper.

A quantity of the flowers which had been deprived of everything soluble in petroleum and in ether was digested with water and the mixture filtered. The concentration of the filtrate was then adjusted so that it represented approximately 10 per cent. of the original flowers. Larvae of the Willow Saw-fly were heavily sprayed with this aqueous extract and appeared to be quite unaffected. Another batch of the larvae sprayed with the preparation made from the petroleum extract was completely killed, notwithstanding the fact that this latter preparation represented a concentration of but 1 per cent. of the flowers.

The flowers which had been successively extracted with petroleum, ether and water were then, after drying, extracted with boiling alcohol. The product removed by this treatment was a brown, resinous material, insoluble in water and in all liquids of an " oily " nature. The only form in which its behaviour towards insects could be tested in anything like a satisfactory manner was that of a fine suspension. Such a preparation was obtained by the gradual addition, with constant stirring, of a concentrated alcoholic solution of the resin to an aqueous solution of the sodium salt of Agral W.B. When this suspension, in a concentration representing about 4 per cent. of the original flowers, was sprayed upon Willow Saw-fly larvae, none appeared to suffer any injury.

It may therefore be concluded that the entire insecticidal value of *Pyrethrum* flowers resides in the petroleum-soluble product. An alcoholic extract of the original flowers will, of course, contain the active principles, but the latter, when removed from the flowers by this solvent, are associated with a relatively large amount of inert material, the presence of which renders it much more difficult to prepare a satisfactory spray fluid. For the preparation of a Pyrethrum Spray Fluid it is therefore considered desirable to employ the extract obtained from the flowers by means of light petroleum or some other anhydrous liquid possessing similar solvent powers.

EXAMINATION OF PLANTS FOR INSECTICIDAL PRINCIPLES.—I.

By F. Tutin.

For some time it has been well known that certain plant products may conveniently be employed for the destruction of insect pests. For instance, the alkaloid, nicotine, is very generally used for this purpose, whilst *Pyrethrum* flowers and *Derris* root may be mentioned as examples of plant products which contain insecticidal principles of a non-alkaloidal nature. From time to time new plants from foreign parts are brought to notice as being reputed to possess value as insecticides, and there are also certain well-known plants which are natives of this country which may also possess value in this direction. It is therefore proposed, as opportunity offers, to submit such of these plants as appear to merit it to an investigation calculated to reveal any insecticidal properties which they may possess. An account is given below of the examination of two such plants, *Oenanthe crocata* and *Inula disenterica*.

Oenanthe Crocata.

The umbelliferous plant, *Oenanthe crocata*, Linné, occurs commonly on the banks of streams and in wet ditches in England and Western Europe, and has frequently attracted attention on account of its poisonous properties. The roots of this plant are in clusters, many of them being of a thick, tuberous nature, somewhat resembling the parsnip in appearance. Numerous cases of fatal poisoning have been recorded, both with human beings and with cattle, which have occurred through eating these roots.

With the object of ascertaining the nature of the toxic principle present in *Oenanthe crocata*, the present author, a number of years ago,* conducted a chemical investigation of the tuberous roots of this plant, when it was shown that the toxic material was a neutral, resinous product, soluble in light petroleum or ether, but insoluble in water.

In view of the great value as insecticides possessed by the pyrethrins, (the active principles of *Pyrethrum* flowers), it has been deemed of interest also to investigate the possibility of employing

*Tutin, Pharmaceutical Journal and Pharmacist, Aug. 26th, 1911.

the toxic principle present in *Oenanthe crocata* for the destruction of insect pests, particularly since its chemical and physical properties, so far as they had been investigated, appear closely to resemble those of the crude pyrethrins.

A number of roots of *Oenanthe crocata* were therefore collected in the early spring and the tubers obtained therefrom were sliced, dried, and ground to a coarse powder. A quantity (432 grams) of the ground material was extracted in a Soxhlet apparatus with alcohol, after which the extract was evaporated, treated with water, and the precipitated resin collected. The latter was thoroughly mixed with purified sawdust and, after drying, subjected to a thorough extraction with light petroleum. On evaporating the petroleum a quantity (1.80 grams) of an orange-coloured resinous residue was obtained.

This petroleum-soluble product, which would contain the greater part, at all events, of the toxic product present in the *Oenanthe* tubers, was dissolved in 108 c.c. of rape oil, and 15 c.c. of Agral W.B. added as an emulsifier. In order to test the activity of this product as an insecticide. 4 c.c. were made up to 200 c.c. with water and emulsification effected by the addition of a few drops of 20% aqueous sodium hydroxide. A number (19) of nearly full-grown larvae of the Large White butterfly, *Pontia Brassicae*, were then thoroughly sprayed with the mixture. In about two minutes 12 of the 19 larvae were dead, the remaining 7, however, commenced, almost at once, to display an abnormal degree of activity, eating ravenously from any portion of the food plant, such as stems, with which they happened to find themselves in contact ; none fed in a normal manner, at the margin of the leaves. Four of these hyperactive larvae were soon seized with convulsions, and died, but the remaining three recovered.

It is evident, therefore that *Oenanthe crocata* does contain a principle toxic towards insects and it is hoped to conduct some further experiments in order to ascertain if any practical use can be made of this product.

Inula Disenterica.

The flowers of *Inula disenterica* (*N.O. Compositae*) have long been popularly supposed to possess properties inimicable to insects, and it is for this reason that the plant in question has acquired the vernacular name of " Fleabane." It was therefore deemed ot interest definitely to ascertain whether these flowers do, in fact, contain any insecticidal product, such as is, for instance, contained in *Pyrethrum* flowers.

A quantity (120 grams) of the dried and ground "Fleabane" flowers was therefore extracted with light petroleum, when 7.74 grams of a deep yellow extract were obtained. This product, when emulsified, and tested against larvae of the Early Thorn Moth, was found to be quite inactive, even when employed in a concentration ten times greater than an analogous *Pyrethrum* preparation which proved fatal to these larvae.

The water-soluble constituents of the flowers and also the resinous product extracted by means of alcohol were likewise found to be devoid of insecticidal properties.

The flowers of *Inula disenterica* may therefore be regarded as useless for the preparation of any practical insecticidal preparation.

THE COMMON GREEN CAPSID BUG (*Lygus pabulinus*) AS A PEST OF SUGAR BEET.

By C. L. Walton and L. N. Staniland.

The following note has been written to familiarise growers of sugar beet with the effects of a pest, the Common Green Capsid Bug (*Lygus pabulinus*), which may become in future a factor of some considerable importance in the economics of sugar beet production. Also, in view of the severe damage effected by this pest to numerous other crops, it has been thought advisable to point out this still further extension of its activities.

Petherbridge and Thorpe* have recently published a detailed description of this pest, which is already well-known and troublesome to many plants. They give a long list of both cultivated plants and weeds on which it has occurred. Amongst these they mention *Chenopodium Bonus-Henricus* (commonly known as "Good King Henry"), and also note that it has been found on several occasions on *Chenopodium album* (known as "Fat Hen"). No mention is made of sugar beet, although the mangold is listed. However, in the monthly summary of Plant Pests and Diseases, published on June 14th, 1929, issued by the Ministry of Agriculture, Mr. A. Roebuck reports, "large fields of beets destroyed by swarms of Capsid nymphs in Lindsey. The stems and cotyledons of the seedlings were punctured." Subsequent to this, a similar attack was reported to us from central Somerset by Mr. J. W. Dallas, then Assistant Agricultural Organiser for that County.

An investigation of the case in Somerset was made by Mr. Dallas and the writers on June 20th, 1929. This outbreak was subsequently reported in the issue of the above-mentioned Plant Pest summary which appeared on July 10th, 1929. An account of this attack is given below.

Features of the Attack.

The affected crop comprised 12 acres of sugar beet, of which about two acres had been sown on April 18th and the remainder on

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* Annals of Applied Biology, Vol. XV., No. 3, August, 1928, pps. 446-472, 2 pls.

May 13th. The rest of the field, adjacent to the later sown portion of the beet, was under main-crop potatoes. The previous cropping history of the field was as follows : flax had preceded the beet in 1928 with a clover ley in 1927 (followed by a catch crop of Brassicas). None of these crops had shown any signs of injury by the pest, but it was noticed by the grower that all weeds among the flax had been injured or destroyed on about one acre of that part of the field in which the beet injury here described occurred. The attack on the sugar beet was limited to a belt varying from 30 to 40 yards in width and extending into the crop from a hedgerow bordering a road, which bounded the field on two sides. Injury was also apparent, in a similar way, in the potatoes mentioned above.

The hedgerow, on examination, revealed Capsid Bug injury on both bramble and bindweed, and there seems little doubt that the pest originated there. This is in keeping with the known life-history as given by Petherbridge and Thorpe, who state " There are two generations per annum. Eggs are laid in the autumn in woody plants such as currants, gooseberries, apples and roses and then migration to herbaceous hosts usually takes place where the summer eggs are laid, the second generation returning to the woody host to lay their eggs."

After hatching the young bugs wandered from the hedge into the crop, and weeds being almost absent therein, attacked the young beet.

That portion of the crop sown on April 18th was much less severely injured than the remainder, and at the time of examination was rapidly " growing away " from the effects of the attack. That portion sown on May 13th, however, was very severely injured. The average number of Capsid Bug nymphs present on each plant was three and the type of injury produced can be best appreciated by reference to the accompanying photograph. The stems and cotyledons (seed leaves) were uninjured, the damage being confined to young leaf growth. In many young plants, this was checked almost to the point of destruction, and resulted in abnormal extension of the cotyledons, which also became much thickened and very brittle. (Slight injury also occurred on a small area of sugar beet, on the opposite side of the road).

Subsequently an insecticide dust containing nicotine was applied and it was reported in due course that the effects were excellent, and that the majority of the affected plants subsequently made good growth.

Young Sugar Beet Plants attacked by the Common Capsid Bug (*Lygus pabulinus*).
Note abnormal growth of the seed leaves.

TAR DISTILLATE WASHES AS A CONTROL FOR APPLE CAPSID BUG: FIELD EXPERIMENTS 1929.*

By L. N. Staniland and C. L. Walton.

Following the work of Smith (1), Tutin (2) has extended the Long Ashton investigations on tar distillate and other spray liquids, the chief result of which has been the demonstration of the great efficiency of the high boiling neutral fraction of tar distillates. He showed also that the remaining fractions possessed little or no egg-killing powers.

Preliminary field trials carried out on apples, plums and black currants during the season 1927-28 (3) demonstrated that a satisfactory commercial control of the Apple Capsid Bug (*Plesiocoris rugicollis*) could be obtained by means of winter spraying. In addition, Aphids and Apple Sucker were completely controlled, whilst in the case of caterpillars and the common Green Capsid Bug (*Lygus pabulinus*) control was of a very high order.

Following these satisfactory initial experiments, the Ministry of Agriculture met the cost of further and more extensive field trials under a wider range of conditions during 1928-29. The results of the latter trials were so convincing that it was considered desirable to make them public at the earliest opportunity, to enable commercial supplies of the spray fluid to be available to fruit-growers for the current winter spraying operations. With this object in view, the results were published in the Journal of the Ministry of Agriculture, in two interim reports (4), (5). The present article embodies the substance of those two reports.

Description of Field Trials.

These trials were planned to include apples, plums and black currants.

*The substance of this paper appeared in the Journal of the Ministry of Agriculture, Sept. and Dec., 1929, and is reprinted, together with the plates and diagrams, with the permission of the Controller of H.M. Stationery Office.

I. Apples.

The experiments were carried out at eleven centres, ranging over nine counties.

The varieties sprayed included Allington, Bramley, Bismarck, Cox's Orange Pippin, Early Victoria, Grenadier, Jubilee, James Grieve, King Edward, Lane's Prince Albert, Lord Derby, Newton Wonder and Prince's Pippin. Each of these was being grown under commercial conditions.

These trials were directed principally to the commercial control of the Apple Capsid Bug (*Plesiocoris rugicollis*) in the egg stage, but observations were included on Aphis, Psylla and Caterpillars. The washes tested comprised not only (1) the Long Ashton wash as used in the trials 1927-28 (already mentioned), but also (2) a modification of this wash, prepared by a commercial firm, in which the tar-distillate used was identical with that employed in the preparation of the Long Ashton wash, but in which the method of emulsification differed, and (3) a well-known proprietary brand of tar-distillate wash, used as a " standard," as in 1927-28.

The dates of application ranged from January 17 to March 9, 1929. It will be noted in Table I. that, at certain centres, two dates are given ; this is due to the fact that certain difficulties arose in connection with the delivery of the Long Ashton wash. The earlier date in each case refers to the application of the modified Long Ashton wash, and the later to that of the Long Ashton wash. It may be recalled that exceptionally bad weather conditions prevailed practically throughout the period of application and, as a result, considerable difficulties in the satisfactory application of the washes were experienced.

In the lay-out of trials, control plots were duplicated or triplicated so as to have unsprayed plots available for comparison in the immediate vicinity of any particular sprayed plots.

II. Plums.

Three centres were used. The varieties included Belle de Louvain, Czar and Prolific.

In this case the information is not so complete owing to the absence of Plum Aphis on any of the trees under trial. Caterpillar was present and some definite results were collected.

III. Currants.

The varieties were Baldwin and Edina.

Here again Aphis was present at only one of the three trial centres, and even then was irregularly distributed. Capsid Bugs were present at all centres, as also were Caterpillars, and some definite results were forthcoming.

Strength of the Washes.

The strengths employed for the three washes were as follows :—

Apples : Proprietary wash used as " standard " (S.) :—12 and 10 per cent. strengths.

Modification of Long Ashton Wash (Mod. L.A.) :—12, 10 and 6 per cent. strengths.

Long Ashton Wash (L.A.) :—10, 8 and 6 per cent. strengths.

Plums : Proprietary wash used as " standard " (S.) :—6 per cent. strength.

Modification of Long Ashton Wash (Mod. L.A.) :—6 and 3 per cent. strengths.

Currants : Proprietary wash used as " standard " (S.) :—10 per cent. strength.

Modification of Long Ashton Wash (Mod. L.A.) :—10, 6 and 3 per cent. strengths.

Long Ashton Wash (L.A.) :—10 and 6 per cent. strengths.

Results.

A. Observations on Leaves and Young Fruits.

Methods of Estimation. The methods of estimation of results were as follows :—In the case of Capsid Bug, estimations by eye were made first of all ; these were followed, in the majority of cases, by actual counts made by means of tally registers. A random sample of 500 was taken as the standard number, but where any such count did not closely agree with the previous eye estimate, further samples of 500 or more were taken. This method was applied in the first place to trusses for the estimation of leaf damage, and later to fruitlets for Capsid Bug markings (shown in Table II.).

Data.

I. Apples.

(*a*) Apple Capsid Bug (*Plesiocoris rugicollis*) : The results obtained are set out in Tables I and II. Table I refers to leaf marking, which is stated as a percentage of trusses marked. Table II treats of young fruits markings in the same manner. It will be observed that the figures given show a very consistent improvement in the degree of control of this pest, as compared with any other washes previously tested.

TABLE I.—Apples. (Capsid Bug Markings on Trusses).

	Centre	Date		Percentage trusses marked by Capsid Bug.								
		Application	Examination	Controls	12 per cent. S.	10 per cent. S.	12 per cent. Mod. L.A.	10 per cent. Mod. L.A.	6 per cent. Mod. L.A.	10 per cent. L.A.	8 per cent. L.A.	6 per cent. L.A.
I	Stawell (Somerset)	Jan. 22 Feb. 8	May 14	70	—	60	10	20	50	0	10	40
II	Cropthorne (Worcs)	Jan. 17 Feb. 22	May 6	30	—	10	—	5	10	Trace	—	5
III	Hampton (Worcs)	Feb. 11 Feb. 22	May 6	76	—	50	—	10	40	0	—	10
IV	Newnham (Glos)	Feb. 4-5	May 13	23	—	16	—	Trace	23	0	—	12
V	Topsham (Devon)	Feb. 8	June 12	40	—	30	—	Trace	—	Trace	—	—
VI	Falmouth (Cornwall)	Feb. 6	June 13	Trace	—	Trace	—	Trace	—	0	—	—
VII	Crockenhill (Kent)	Mar. 8	May 24	13	—	10	—	Trace	—	0	—	—
VIII	Wilmington (Kent)	Mar. 9	May 24	93	—	30	—	5	—	10	—	—
IX	Sompting (Sussex)	Feb. 23	May 23	52	—	50	—	14	21	—	—	—
X	Friday Bridge (Isle of Ely) ..	Mar. 6-7	May 28	42	18	35	6	10	—	—	—	—
XI	Burwell (Cambs) A	Mar. 6	May 29	30	10	8	6	8	—	—	—	—
	B	Mar. 8	May 29	16	—	7	—	7	—	—	—	—

TABLE II.—Apples. (Capsid Bug Markings on Fruitlets).

	Centre	Date		Percentage young fruit marked by Capsid Bug.					
		Application.	Examination	Controls	10 per cent. S.	10 per cent. Mod. L.A.	6 per cent. Mod. L.A.	10 per cent. L.A.	6 per cent. L.A.
II	Cropthorne (Worcs)	Jan. 17 Feb. 22	June 18	66	40	18	30	6	26
III	Hampton (Worcs)	Feb. 11 Feb. 22	June 17	55	43	8	32	5	26
IV	Newnham (Glos)	Feb. 4-5	June 17	66	38	10	23	4	12
V	Topsham (Devon)	Feb. 8	June 12	90	50	5	—	Trace	—

(*b*) Caterpillars, Aphis and Apple Sucker: The general results obtained were excellent, and of the same order as shown in the above tables. Actual figures are omitted from this paper, which is principally designed to demonstrate the results obtained against Capsid Bugs. The caterpillar attacks on the control plots at all centres were exceptionally severe.

Among the definite results obtained the following may be stressed :—

(*a*) All the sprays at all strengths used effected complete control of Aphis and Apple Sucker.

(*b*) As regards caterpillars it was shown that good commercial controls were obtained by all three sprays at 10 per cent. strength.

At 6 per cent. strength, the proprietary wash (S) did not give this commercial control, but the Long Ashton wash (L.A.) gave results equal to those obtained by the 10 per cent. proprietary wash (S.).

The Modified Long Ashton spray (Mod.L.A.) gave results slightly inferior to the Long Ashton (L.A.) spray at the same strengths.

At 10 per cent. strength the Long Ashton spray (L.A.) gave a markedly superior control as compared with the proprietary spray (S) at the same strength.

II. Plums.

(*a*) Aphis: As already stated no results were obtained owing to absence of the pest.

(*b*) Caterpillars: The results were equivalent to those given above for apple.

III. Black Currants.

(*a*) Capsid Bugs (largely *P. rugicollis* but some *Lygus pabulinus* present): At Centre I (Dunnington, Worcs.) the figures obtained for Capsid Bugs were as follows :—

Plot.	Estimated Percentage of Leaves Marked.
First Control	70
10 per cent. L.A.	20
10 per cent. Mod. L.A.	30
10 per cent. S.	60
Second Control	60

Two other trials at Cheltenham and Newnham gave similar results, but details are omitted here for the sake of brevity.

(*b*) Aphis : The position with regard to aphis has already been stated. It is worthy of note, however, that at the centre where aphis was present it was controlled by the Modified Long Ashton spray (Mod.L.A.) at 3 per cent. strength. The proprietary spray (S.) and Long Ashton spray (L.A.) were not applied at 3 per cent. strength.

B. Observations on Mature Fruits.

Late frost damage, unfortunately, resulted in absence of fruit from three centres (Isle of Ely, Cambridge and Somerset). At another centre (Cornwall), fruit records were not dealt with because the attack of Capsid Bug there was extremely light. Owing to local factors, which were found to have complicated the results at the Sussex centre, this is also omitted. At the remaining six centres, both good crops of fruit and incidence of the pest rendered these trials a thorough test ; it is with these centres alone, therefore, that this part of the present article is concerned.

Methods of Estimation.

The methods employed in estimating the amount of Capsid Bug damage differed slightly from those used for the observations on foliage and young fruits described in the previous section.

Eye estimations were omitted and all figures are the result of actual countings and weighings of the complete crop from trees. All counts were made by means of tally registers. Samples of 1,000 fruits were taken as the standard number and the percentage figures given are the result of the counts of these samples.

In some instances, the entire crop on each plot was dealt with, but often it was necessary to restrict the fruit to that from a limited number of trees. In certain cases where there was a marked difference in the size of trees on any given plot, adjustments were made in the number of trees from which the crop was picked in order to obtain cropping tree surfaces as nearly equal as possible. Further, this principle had to be applied to certain groups of control trees on which the crop was very light in order to get enough fruit for counting purposes.

The fruit was graded into two samples : those apples showing definite Capsid Bug injury, whether pronounced or slight only ; and those entirely free. Such rigorous methods resulted in some

perfectly marketable fruit being relegated to the former class, although the bulk of fruit in that class was, in most cases, definitely unsaleable. Without such a rigorous grading no complete and reliable figures of Capsid Bug damage could have been obtained. The samples from each plot were weighed separately, after grading into the two classes mentioned, the total crop weights of the trees used thus being the sum of these two figures.

Strengths of Washes.

The information given below regarding strengths of washes, refers only to those centres dealt with in this section of the paper :—

Proprietary wash used as "standard" (S.) :—10 per cent. strength.

Modification of Long Ashton Wash (Mod. L.A.) :—10 and 6 per cent. strength.

Long Ashton Wash (L.A.) :—10 and 6 per cent. strength.

Data.

All results given here refer to Capsid Bug markings on mature apples.

The figures in brackets in column 2 of the tables following refer to the number of trees from which the crop was taken. With the exception of the table in the summary, all percentages are worked out to the nearest whole number.

TABLE III.

CENTRE II. Cropthorne, Worcestershire.

Dates of application of washes* : January 17, February 22, 1929.
Date of final examination : September 27, 1929.

Variety.	Treatment.	No. of Fruits marked by Capsid Bug. (Per cent.)		Weight of Fruit marked by Capsid Bug. (lbs.)	Weight of Fruit unmarked by Capsid Bug (lbs.)
Lane's Prince Albert.	Control	(9)	90	88	10
	10 per cent. S.	(4)	87	112	27
	10 per cent. Mod. L.A.	(5)	52	73	104
	10 per cent. L.A.	(6)	11	18	106
	6 per cent. Mod. L.A.	(5)	82	46	33
	6 per cent. L.A.	(5)	45	177	233

* The reason for the separate dates being given for the application of the washes is due to the fact that, as already stated, certain difficulties arose in connection with the application of the washes.

TABLE IV.

CENTRE III. Hampton, Worcestershire.

Dates of application of washes: February 11, February 22, 1929.
Date of final examination: September 26, 1929.

Variety.	Treatment.		No. of Fruits marked by Capsid Bug. (Per cent.)	Weight of Fruit marked by Capsid Bug. (lbs.)	Weight of Fruit unmarked by Capsid Bug. (lbs.)
Prince's Pippin.	Control	(2)	90	36	5
	10 per cent. L.A.	(4)	8	27	266
	6 per cent. L.A.	(3)	51	47	60
Lane's Prince Albert.	Control	(6)	70	71	34
	10 per cent. S.	(6)	74	55	32
	10 per cent. Mod. L.A.	(6)	14	10	51
	6 per cent. Mod. L.A.	(6)	59	100	66

TABLE V.

CENTRE IV. Newnham, Gloucestershire.

Dates of application of washes: February 4 and 5, 1929.
Date of Final Examination: September 30, 1929.

Variety.	Treatment.		No. of Fruits marked by Capsid Bug. (Per cent.)	Weight of Fruit marked by Capsid Bug. (lbs.)	Weight of Fruit unmarked by Capsid Bug. (lbs.)
King Edward VII.	Control	(12)	60	24	25
	10 per cent. S.	(12)	75	73	28
	10 per cent. Mod. L.A.	(8)	24	62	230
	10 per cent. L.A.	(8)	11	29	240

The caterpillar attack on the control trees at this centre was very severe, and one of the results of this, coupled with severe Capsid Bug damage, was very light crops on the unsprayed trees.

TABLE VI.

CENTRE V. Topsham, Devonshire.

Date of application of washes: February 8, 1929.
Date of final examination: September 23, 1929.

Variety.	Treatment.		No. of Fruits marked by Capsid Bug. (Per cent.)	Weight of Fruit marked by Capsid Bug. (lbs.)	Weight of Fruit unmarked by Capsid Bug. (lbs.)
Lane's Prince Albert.	Control	(4)	65	270	160
	10 per cent. S.	(4)	36	100	270
	10 per cent. Mod. L.A.	(8)	11	10	130
	10 per cent. L.A.	(2)	2	10	470

It should be noted, in relation to the above table, that the crop was taken from eight trees in the case of those sprayed with Modified Long Ashton spray at 10 per cent. strength. This was done in an attempt to compensate for the small size of the trees.

TABLE VII. A.

CENTRE VII. Crockenhill, Kent.

Date of application of washes: March 8, 1929.
Date of final examination: September 17, 1929.

Variety.	Treatment.		No. of Fruits marked by Capsid Bug. (Per cent.)	Weight of Fruit marked by Capsid Bug. (lbs.)	Weight of Fruit unmarked by Capsid Bug. (lbs.)
Bismarck.	Control	(6)	64	214	159
	10 per cent. Mod. L.A.	(6)	8	25	320
	10 per cent. L.A.	(6)	3	9	377
Lord Derby	Control	(6)	76	184	56
	10 per cent. S.	(6)	95	337	31
	10 per cent. Mod. L.A.	(6)	30	233	170

We are indebted to Mr. M. D. Austin, of the South-Eastern Agricultural College, for kindly furnishing us with the following figures relating to the grading and weighing of the fruit from trees of the variety "Allington Pippin" at this centre. Only weights were taken, no counts being made. We have accordingly set out below a separate table dealing with the figures.

TABLE VII. B.

Variety.	Treatment.		No. of Fruits marked by Capsid Bug. (Per cent.)	Weight of Fruit marked by Capsid Bug. (lbs.)	Weight of Fruit unmarked by Capsid Bug. (lbs.)
Allington Pippin.	Control	Row 1 (3)	28	102	258
	Control	„ 2 (3)	50	161	159
	10 per cent. L.A.	„ 1 (3)	9	34	350
	10 per cent. L.A.	„ 2 (3)	11	60	497

TABLE VIII.

CENTRE VIII. Wilmington, Kent.

Date of application of washes: March 9, 1929.
Date of final examination: September 18, 1929.

Variety.	Treatment.		No. of Fruits marked by Capsid Bug. (Per cent.)	Weight of Fruit marked by Capsid Bug. (lbs.)	Weight of Fruit unmarked by Capsid Bug. (lbs.)
Lord Derby.	Control	(6)	100	126	0
	10 per cent. S.	(4)	83	200	12
	10 per cent. Mod. L.A.	(6)	65	288	159
	10 per cent. L.A.	(6)	97	447	40
Grenadier.	Control	(6)	57	—	—
	10 per cent. S.	(6)	49	—	—
	10 per cent. Mod. L.A.	(6)	33	—	—
	10 per cent. L.A.	(6)	37	—	—

It will be observed that no weights were taken in connection with the fruit of the variety "Grenadier" at this centre. For the count of the fruit of this variety thanks are due to the grower concerned.

It has already been stated that, of the eight centres where the Long Ashton wash was applied, this centre was the only one where leaf damage by Capsid Bug exceeded "trace" on the sprayed trees. It was subsequently reported, during the young fruit period, that Capsid Bug injury had continued to increase on all the plots. At the final examination this observation was substantiated, as will be seen from the figures given above. The best control of Capsid Bug was on the Modified Long Ashton wash plot, this being the only instance throughout the whole of the trials where the Long Ashton wash failed to give the best result. It will be further observed that, in the case of all the washes used at this centre, the pest damage figures are very considerably higher than those at any other centre. This abnormal result would suggest that some special local circumstance was responsible for the deviation from the other trial centres, and it is, therefore, proposed to make special investigation at this centre next year.

Relation between the Time of Application of the Spray and the Control of Capsid Bug.

It has been observed in the past that a greater degree of control of Capsid Bug* was obtained when the tar-distillate washes of the ordinary type were applied near to the time of hatching of the eggs. It will be seen from the information given in this, and previous papers, that the results obtained by the use of the Long Ashton wash were as effective in the case of early applications of the wash as in those instances when it was applied late.

In explanation of this, Mr. F. Tutin, as a result of unpublished experiments, makes the following suggestion :—

> The time that the eggs are most easily killed is shortly before the normal hatching period. The older commercial types of tar-distillate wash in use contain tar-acids and, in addition, a considerable proportion of low-boiling material. The tar-acids are washed out by rain, and the low-boiling material evaporates, with the result that there may remain only about 30 per cent. of the original material present on the tree at the time when the eggs become susceptible to killing, if the wash was applied early in the dormant season. The Long Ashton wash

* This remark applies also to other pests such as aphis, apple sucker and caterpillars, but particularly to Capsid Bug, the egg of which is much more difficult to kill

contains no tar-acids, and the material boils above 280° C. and is relatively non-volatile, thereby ensuring that the major portion of the oil remains upon the trees until the eggs are killed.

The Long Ashton wash may, therefore, probably be applied at any time throughout the dormant season without any serious risk of loss of efficiency.

Summary of Results.

(1) *Apple Capsid Bug* (*Plesiocoris rugicollis*): The results given in Table 1—VIII show clearly that the Long Ashton spray at 10 per cent. strength gave a consistent control of such a high order that further spraying in the spring for this pest was rendered unnecessary.

The outstanding features demonstrated by the foregoing information and tables are set out in graphic form in Diagram I.

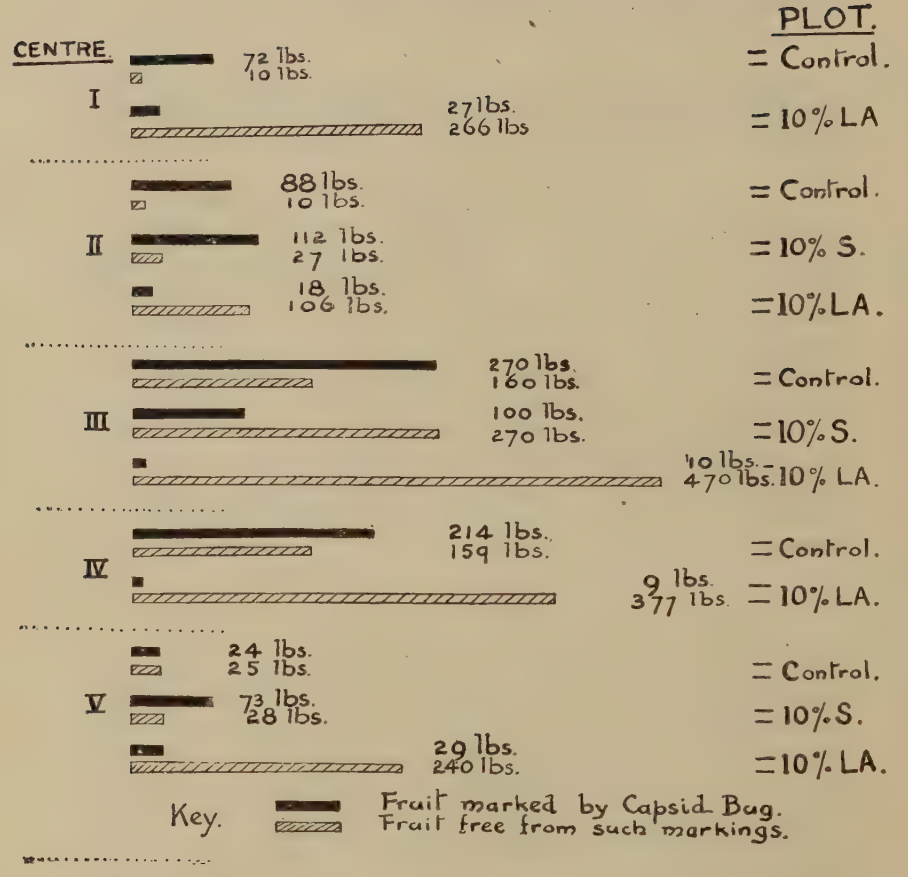
The salient points are (*a*) the great reduction by the use of the Long Ashton wash at 10 per cent. strength in the amount of fruit marked by Capsid Bug as compared with the unsprayed trees and those sprayed with a commercial wash of the old type at the same strength; and (*b*) the increase in weight of clean fruit as well as total weight of crop, which was a noticeable feature in several instances.

The following table, Table IX, summarises the results for such of the centres as provide data which can properly be included in a single table. Those centres are Cropthorne, Newnham-on-Severn and Topsham. In each of these cases the washes were applied to one variety of apple only, Lane's Prince Albert, at Cropthorne and Topsham, and King Edward VII at Newnham. At the three centres not dealt with in this table, more than one variety of apple had to be included in the spraying programme owing to the lay-out of the blocks of trees available for the trials and accordingly, as reference to the data relating to these centres will show, the results did not lend themselves to inclusion in a composite table of this description.

Table IX.

Treatment.	Average number of fruits marked by Capsid Bug (Per cent.)	Total weight of fruit marked by Capsid Bug (lbs.)	Total weight of fruit unmarked by Capsid Bug (lbs.)	Total weight of fruit (marked and unmarked) (lbs.)	Average weight of fruit marked by Capsid Bug Per cent.)
Control	71.6	382	195	577	66.2
10 per cent. S.	65.3	285	325	610	46.7
10 per cent. Mod. L.A.	29.0	165	724	889	18.5
10 per cent. L.A.	8.0	57	816	873	6.5

DIAGRAM I.



Weights of fruit marked by Capsid Bug and fruit free from such markings from five centres. The weights are shown graphically and to scale and indicate the condition of the fruit on (1) unsprayed trees (2) those sprayed with an ordinary commercial tar-oil wash at 10 per cent. strength and (3) those sprayed with the Long Ashton spray at the same strength.

Note the increases in total weight of fruit as well as in the percentage of clean fruit

S = Proprietary wash used as "standard."
Mod. L.A. = Modification of Long Ashton wash.
L.A. = Long Ashton wash.

It is evident therefore that a commercial control of Apple Capsid Bug has been obtained by the use of a tar-distillate wash, made according to the formula devised at this Station by Mr. F. Tutin,, and that at 10 per cent. strength, the results were such that further spraying in spring against this pest was rendered unneccessary.

PLATE I.

Early Victoria tree sprayed with the Long Ashton Tar-distillate spray at 10 per cent. strength. Photograph taken June 3rd, 1929, at Centre I (Stawell, Somerset).

Note freedom from all pests, including Capsid Bug.

PLATE II.

Unsprayed tree adjoining that shown in Plate I at Centre I, photographed on same day. Note severe caterpillar and Capsid injuries to foliage.

The blossom, it should be noted, was damaged by frost at this Centre.

PLATE III.

Sample branch of Prince's Pippin tree, at Centre III (Hampton, Worcs.) from block of trees sprayed with the Long Ashton Spray at 10 per cent. strength. Photographed June 17th, 1929.

Note clean fruit and foliage.

PLATE IV.

Sample branch from tree, adjacent to that shown in Plate III, from a block of trees unsprayed.

Note severe caterpillar injury to leaves and Capsid bug damage to fruitlets.

PLATE V.

Portion of tree (variety King Edward) at Centre IV (Newnham, Glos.) sprayed with the Long Ashton spray at 6 per cent. strength, showing vigorous shoot growth and freedom from injury. Photographed July 5th, 1929.

PLATE VI.

Portion of tree of same variety as in Plate V on Control plot. Showing severe caterpillar injury which, in conjunction with Capsid Bug damage, has resulted in poor shoot growth. Photographed July 5th, 1929.

PLATE VII.

Prince's Pippin tree, sprayed with the Long Ashton spray at 10 per cent. strength, adjoining that shown in Plate VIII. Photographed on the same day.

PLATE VIII.

FIG. 1.—Prince's Pippin tree, unsprayed and adjoining that shown in Plate VII. Note severe Capsid Bug injury to fruit. Photographed September 26th, 1929, at Centre III, Hampton, Worcs.

PLATE IX.

Total fruit picked from *four* Prince's Pippin trees, sprayed with the Long Ashton spray at 10 per cent. strength. The fruit has been graded as labelled. Photographed at Centre III, Hampton. Worcs., September 26th, 1929.

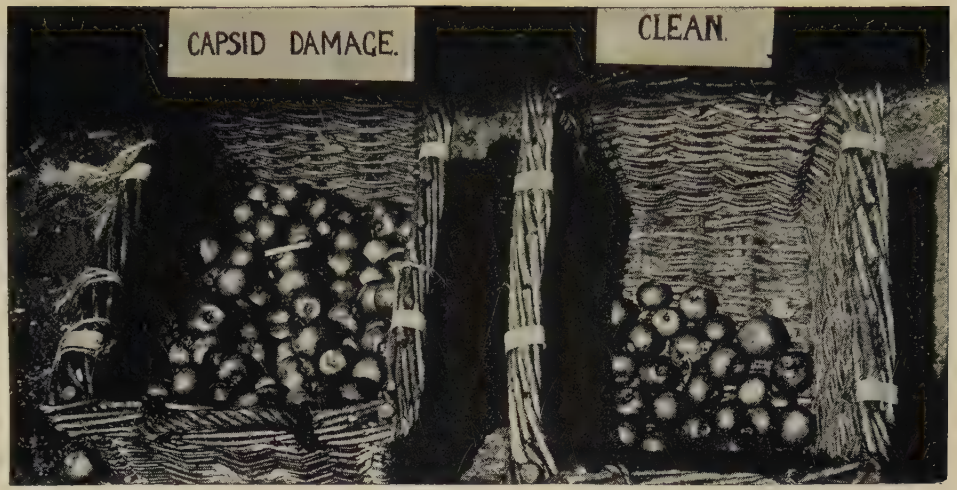


PLATE X.

Total fruit picked from *two* Prince's Pippin trees unsprayed. The fruit has been graded as labelled. Photograph taken at Centre III, Hampton, Worcs., September 26th, 1929.

(2) *Caterpillars*: The results also demonstrate that the Long Ashton spray at 6 per cent. strength, and the Modified Long Ashton spray at the same strength, give an effective commercial control of all caterpillars present in the egg stage at the time of application. It may be recalled that hitherto tar-distillate washes have had to be used at 10 per cent. strength in order to effect similar control. The above remarks apply equally to caterpillars on apples, plums and black currants.

(3) *Capsid Bugs* (*P. rugicollis and Lygus pabulinus*) *on Currants*: Although a useful commercial control was obtained by the use of the Long Ashton spray at 10 per cent. strength, the results were not of the same high order as those obtained against Capsid Bug on apples.

Recommendations.

In view of the results obtained, the following recommendations are made concerning the use of tar-distillate sprays based on the Long Ashton formula :—

(1) *Apples.*

(*a*) Where trees are infested with Capsid Bugs, the spray at 10 per cent. strength during the dormant season (December, January or February) should be used.

(*b*) Where Capsid Bugs are absent, the spray at 6 per cent. strength should be used.

(2) *Plums.*

In view of the effectiveness of the Long Ashton spray at 6 per cent. strength against caterpillars and aphis, this strength is advised. The effect of the spray at lower strengths is being investigated.

(3) *Currants.*

Where Capsid Bugs are present, the spray should be used at 10 per cent. strength. If Capsid Bugs are not present, 6 per cent. strength should be used.

Acknowledgments.

It may be recalled that the cost of these extensive trials has been met by a special grant from the Ministry of Agriculture. The writers have again to acknowledge further assistance by Advisory

Officers, County Staffs, growers and others, and also desire to express their indebtedness to Mr. F. Tutin for his constant help and advice throughout the progress of the work. Mr. G. H. Jones, of the Long Ashton Station, is responsible for the excellent photographs reproduced as illustrations.

Thanks are also due to the Ministry of Agriculture for permission to use considerable portions of the text of the articles published in their Journal during 1929, and the loan of blocks.

Articles Already Published Relating to the Long Ashton Tar-Distillate Wash.

(1) Smith, L. E. (1926) "Investigations on Tar-Distillate Sprays." *Ann. Rept. Agric. and Hort. Res. Stat., Long Ashton.*

(2) Tutin, F. (1928) "Investigations on Tar-Distillate and other Spray Liquids: I.—Improvements in the Methods of Preparation of Tar-Distillate Spray Fluids." *Ann. Rept. Agric. and Hort. Res. Stat., Long Ashton.*

(3) Staniland, L.N., and Walton, C. L. (1928) "The Long Ashton Tar-Distillate Wash: Field Experiments, 1927-28." *Journal of the Ministry of Agriculture, Nov.*, 1928, *p*, 731.

(4) Do. Do. (1929) "The Long Ashton Tar-Distillate Wash: Field Experiments, 1929." *Journal of the Ministry of Agriculture, Sept., p.* 517.

(5) Do. Do. (1929) "The Long Ashton Tar-Distillate Wash: Field Experiments, 1929, II." *Journal of the Ministry of Agriculture, Dec., p.* 828.

THE RASPBERRY AND LOGANBERRY BEETLE AND ITS CONTROL: SOME EXPERIMENTS WITH A PYRETHRUM EMULSION SPRAY.

By C. L. Walton.

The Beetle and Its Ravages.

Byturus tomentosus, generally known as the Logan or Raspberry Beetle, is the most serious pest with which British growers of those two fruits have to contend. Indeed the infestations may become so severe as to ruin the bulk of the crops and render the fruit quite unfit for canning or bottling. Blackberries also suffer heavily, and there is little doubt that it was from wild plants of this berry that the infestation of cultivated Rubi arose in the first instance and is still being constantly renewed.

To the general accounts of the life history, etc., given by Theobald (1), Warburton (2) and others, it does not seem needful to add, except to stress the following points. The adult beetles are on the wing in numbers for a considerable period prior to the opening of the flowers of Logan and Raspberry and during that time frequent other flowers, notably those of apple and pear. At Long Ashton specimens have been taken from plants as diverse as the Currant and Lilac.

Furthermore, to quote Lees, (3) (who also noted that the beetle could be found in apple flowers) "They feed on the tissue of the base of the flower, the nectaries being probably especially attractive. As they feed they destroy the base of the stamens, but otherwise do not do much direct damage." Warburton (2) states that "They pierce buds and prevent many of them from developing at all. Later they attack open blooms and feed upon stamens and petals. Much harm is done in these early stages . . . . ." After a detailed examination of some 18,000 fruits, I am inclined to the view that the injury caused by the adult beetles at this stage is often by no means negligible. Apart from considerable scars left on the disc and base of the receptacle (the type of injuries mentioned by Lees) the basal and peripheral drupes of such flowers frequently remain shrivelled and green, causing such fruits to be imperfect and to some extent malformed. These shrivelled "seeds" generally showed a puncture or scar. This type of injury may appear in cases where there is no larval damage to the receptacle, etc., and,

in my experience, is certainly more abundant and serious in those plantations infested with beetles than in others. It seems highly probable that such injuries may be caused by the feeding habits of the adult beetles.

Resumé of Previous Investigations on Control.

In the absence of any corresponding review elsewhere, a short resume of the progress of control measures in this country is perhaps called for here before proceeding to the account of the present investigations.

Theobald (1) advises pruning and burning of canes from infested plantations, and the removal of brambles from the vicinity. The hoeing, liming, etc., of the ground after attack; jarring over tarred sacks, etc., and (from experiments in 1903 and 1908) the use of Arsenate of Lead as a spray.

In 1917 Lees (3) tested a combined nicotine-paraffin emulsion soft soap spray " which had already given good results against the beetle on a small scale." An infestation of 100% was reduced to one of 33%, by three double sprayings in 3 weeks. It was found necessary to spray with paraffin emulsion ahead of the combined spray, in order to dislodge the beetles and secure a good kill.

In 1919 Lees (4) states of the above " The method though successful was rather expensive, and cannot therefore be considered as thoroughly satisfactory." Having noted that logans growing in soil well cultivated during the summer suffered less than others, Lees carried out a field trial designed to test out this method of control. Figures are given in the paper just mentioned and the results are summarised as follows. " There was a marked increase of infestation where no cultivation was done, but the difference between any of the treated rows was not sufficient to draw any definite conclusion."

Lees and Peren published in 1920 (5) the results of further trials adding soap to a lead arsenate spray. No scorching occurred and the total percentage of infestation was reduced from 24 to 15; only two sprayings were made.

Again in 1921 the same workers (6) report on the results of three sprayings with Arsenate of Lead, the formula used being Arsenate of Lead 4lbs., water 100 gallons. The applications were made when approximately " one third of the bloom was out, the second when two thirds were out, and the third when the bushes were in full bloom." The sprayed berries in this trial averaged 4.9% infested and the unsprayed 19.8%.

In 1922, further and similar trials at Long Ashton were carried out, (7), (8), and the results of three consecutive years spraying are given in the articles cited, showing a consistent reduction of infestation on both the sprayed and control plots.

	Sprayed.	Unsprayed.
1920 ..	15 %	.. 24 %
1921 ..	4.9 %	.. 19.8 %
1922 ..	2.6 %	.. 9.1 %

In 1925, the Ministry of Agriculture and Fisheries (9) referring to this pest, stated " Unfortunately no satisfactory means of dealing with the pest has yet been discovered . . . . Under experimental conditions, spraying the open bloom with lead arsenate has given promising results, but is open to objection, firstly on account of the danger of poisoning bees, and secondly because the length of the flowering period would render several sprayings necessary."

In spite of these objections it would appear from the literature quoted that the method of Lees and Peren's did effect a commercial control, and that any spray method would have to encounter the same difficulty, namely the prolonged flowering period of both raspberry and loganberry. A more real danger would seem to be in the persistent use of sprays containing arsenic. Be that as it may, the method does not seem to have come into very general use, since persistent complaints continue to be received from growers as to continued heavy infestations and losses.

Experiments with Pyrethrum Sprays.

One of the problems under consideration when the writer took up duties at Long Ashton in October 1927, was the discovery, if possible, of some effective spray or dust which would not possess the poisonous properties of Lead Arsenate. The following pages detail the progress made so far in this enquiry in respect of the use of pyrethrum as the toxic agent.

Tutin (10) states " The insecticidal properties of the flowers of certain species of *Pyrethrum* have long been known, but as yet no satisfactory preparation of the active principles of these flowers adapted for employment in the field as a spray appears to have been devised " and refers to two recent sources of information (11) (12).

Tutin shows that the active principles present in Pyrethrum flowers (*P. cinerariaefolium*) may be readily extracted by means of light petroleum, and that the extracted active principles, when dissolved in a fatty oil, (such as Rape oil), may be emulsified. An emulsion prepared in this manner, representing a concentration of 1 % of the original flowers, when used as a spray, was rapidly fatal to a number of insect species, but caused no damage to vegetation.

Several references have recently been made in various journals and reports regarding progress made in the growth of *P. cinerariaefolium* in Britain, whilst articles by Austin and Theobald 1928 (13) and Austin 1929 (14) refer to experiments on various insects carried out at Wye, using aqueous and alcoholic extracts respectively. No mention is made in these, however, of *Byturus tomentosus* as an object of test.

In Tutin's paper (9) details are given as to the effects of his pyrethrum spray on a number of insects, under laboratory conditions and including the Logan Beetle. He also refers to some small scale field trials conducted by the author. Details of these not having been published previously, they will be given here before the more extensive trials of 1929 are described.

Field Trials in 1928.*

It was not anticipated at the outset that any field trials could be made during the summer of 1928. Since, however, the laboratory trials were so promising and were so expeditiously carried through, it was decided to attempt something that year, however small, since any experience of field conditions would be of great value for more extensive work in 1929. The limited amount of the spray material available only allowed of one spray application being made : this was applied to heavily infested loganberry plants situated (*a*) in gardens in the village of Long Ashton and also (*b*) on a commercial plantation in Herefordshire.

In the case of (*a*) Logans were sprayed on June 6th by means of a hand machine, approximately one-third of the flowers being set, one-third being open, and one-third still in bud. An equal length of canes was reserved as a control. Six pickings were made from both plots between June 26th and July 27th, the entire crop from both sprayed and control canes being dealt with—24 yards run of canes in all. In all 677 fruits were picked and the effect of the spray was clearly seen. On July 7th the infestation on the sprayed plot was 53% and on the control 56%. On the 10th the sprayed plot gave 39.37% and on the control 79.16%. On the 13th the figures were 58% and 87.57% respectively.

In (*b*) an area of 1 17 acre was sprayed by means of a knapsack, the flowering conditions being similar to that of (*a*). The weather was dull and few adult beetles were on the flowers, only 27 being found on 500 flowers.§

* The Spray Fluid used in the Trials described in this paper is that described by F. Tutin, this Report, p. 93.

§ During the afternoon the sun shone, and in another field 37 Beetles were obtained from 100 flowers.

A picking was made on July 20th when (as nearly as could be judged) the fruits from the sprayed blooms were ready. 1,200 fruits were examined—600 from sprayed and 600 from control canes.

The controls showed an infestation of 40.87% and the sprayed 30%. The owners kindly carried out further counts involving some thousands of fruits, but no reduction was shown by these.

It may be mentioned here that a row of Raspberries was sprayed at Long Ashton on May 18th just as the first flowers opened in order to test any deterrent effect the spray might have. Subsequent counts showed no significant difference between the sprayed and control plots. The average infestation here proved to be only 9.5% (between June 26th and July 13th on 1594 fruits examined). This brings out an interesting point. It has been stated that where Logans and Raspberries are grown in close proximity, the beetles show a decided preference for Logan flowers for purposes of oviposition. This is borne out by the above figures since the Raspberries mentioned were situated some 30 yards from the Logans used for experiment (*a*) where the average infestation (July 6th to 13th) was 74.24%. The highest infestation recorded on the Raspberries was 33% on the 13th July.

In another garden in Long Ashton, a short row of Logans showed an infestation of 68.3% on July 13th, whereas a row of Raspberries only separated by a narrow path gave an infestation of 24.5%.

Mr. F. Tutin informs me that he has noted a corresponding preference for Phenomenal Berry when these are grown in proximity to Logans. It would seem that these facts might be turned to practical account, by the use of these preferred plants, either inter-planted as "traps" or around the margin of new plantations. The latter alternative is suggested since experienced growers state that the infestation of these proceeds progressively inwards from the margins and hedges. Such "traps" could be sprayed, or all fruits picked and destroyed. An experiment along these lines certainly seems indicated.

Lees and Peren (4) state for their 1920 field trials that "It is clear . . . . that in the unsprayed portions there is a well marked increase in the number of infected berries as the season advances. This is due to unknown causes, but may be attributed to the increasing number of beetles that come out of winter quarters as the season progresses."

Whether or not that explanation is correct, it will be seen from figures given for the 1928 field trials, and those that follow (for 1929) that this progressively increasing infestation is a notable fact, and can be seen in both control and sprayed plots.

Field Trials in 1929.

These were twofold (A) on Logans, in gardens at Long Ashton and (B) on Raspberries near Evesham. The former was intended as the main trial, but owing to very serious frost injury to the plantations originally selected, these had to be abandoned, and the major trial was carried out on a commercial plantation of Raspberries

Loganberries.

Heavily infested plots were selected and sprayed with an efficient bucket pump on June 1st, 7th and 21st, part of each plot being left unsprayed as a control. Rain and high wind caused delay in applying the third spraying. Six pickings were made, and the results are summarised in Table A.

TABLE A.

LOGANBERRY TRIALS, 1929.

Centre.	Dates of Picking.	Control.		Sprayed.	
		Nos. of Fruits Counted.	% Infestation.	Nos. of Fruits Counted.	% Infestation.
A.	11/7/29	100	72.2	16	0
	17/7/29	300	80.3	252	20.6
	22/7/29	200	86.0	300	28.7
	25/7/29	200	82.5	300	28.3
	29/7/29	200	76.5	290	22.3
	1/8/29	100	89.0	250	34.8
Totals A.	..	1100	81.8	1408	22.5
B.	11/7/29	233	76.4	194	16.0
	17/7/29	400	70.0	500	9.8
	22/7/29	500	63.7	500	16.4
	25/7/29	500	66.2	500	16.4
	29/7/29	500	66.2	500	18.2
	1/8/29	249	65.2	500	24.2
Totals B.	..	2482	67.9	2694	16.82

Raspberries.

A heavily infested plantation near Evesham was used for this trial, the variety being Lloyd George. Three fifths of an acre was sprayed on June 5th, 19th and 25th, when the flowers were approximately one-third, two-thirds and fully open. The second application was about five days later than intended owing to high winds. The owner considered that the first and last sprayings could be regarded as "best dates." 175 gallons of wash were used on June 5th, being at the rate of about 300 gallons per acre. The spray was applied by means of automatic knapsacks by two men per row.

When the first spraying commenced, 100 typical flowers were examined and yielded 65 beetles. After the sprayers had passed another 100 flowers gave 12 beetles ; these were kept for 24 hours, when 8 were dead, the other 4 recovering.

On July 10th, just as the grower commenced his first picking, random samples of 200 fruits were taken from both sprayed and control plots and examined at once. These yielded as follows :—

	Clean.	Infested.	% Infestation.
Sprayed ..	173 ..	27 ..	13.5
Control ..	70 ..	130 ..	65.0

this showing a reduction of infestation of 51.5%.

Five successive commercial pickings from the plot were made in due course by the grower, and a day prior to each, 1,000 fruits were picked from the sprayed and control plots respectively (10,000 in all) and placed in a 2% formalin solution in screw top jars and the whole finally brought to Long Ashton, where they were subsequently examined, one by one, in the laboratory.

The actual picking was done by the same person throughout, after preliminary instruction. This picker took a random sample of 200 from each row per pick (100 from each side of each row) and placed these in a separate labelled and numbered jar, so that each row could be compared separately throughout.

The fruits were picked on the stalk, and were pulled apart at counting, when a considerable proportion (especially from the first and second pickings), were examined under a low power Zeiss binocular microscope. During this process a total of 173 were rejected either through prior disease or injury other than that caused by *Byturus* which rendered them unsuitable for critical work. The results of these counts are summarised in Table B.

TABLE B.

Raspberry Trials, 1929.

Dates of Picking.	Control.		Sprayed.		% Difference Control and Sprayed.	
	No. of Fruits Counted.	% Infestation.	No. of Fruits Counted.	% Infestation.		
10/7/29	992	47.0	964	7.0	40.0	41.1
15/7/29	978	60.7	985	10.9	49.9	
18/7/29	994	66.4	991	17.9	48.5	
22/7/29	992	53.3	973	20.5	32.9	27.1
24/7/29	987	56.0	833	34.7	21.3	
Totals	4943	56.7	4884	18.2	38.5	

The author is indebted to the grower for the following figures relating to crop weights and picking dates in the 1929 field trials on raspberries. The proportionate crop weights for the five commercial pickings were 65, 65, 104, 61 and 38 respectively out of a total of 333.

Reference to Table B will show that the average percentage infestation of the control plot was 56.69, whilst that of the sprayed plot was 18.17, the difference indicating an average reduction of infestation of 38.50%. The total crop weight being represented by the figures 333, it is evident that for the first three pickings, representing 70% of the total crop, the reduction of infestation was 46.13%, whilst for the last two pickings, representing 30% only of the crop, the reduction was but 27.09, a matter of considerable economic significance. This is a point which will call for more detailed consideration as this work becomes further advanced.

Blackberries.

Several large bushes of a special garden variety were sprayed twice—June 28th and July 10th—in a private garden at Long Ashton by the owner. Unfortunately no controls were left; since comparison was therefore impossible, no counts were made. The owner estimates the subsequent infestation at 20% out of a very heavy crop and states that in previous years the majority of fruits were ruined by the larvae of *B. tomentosus*.

Acknowledgments.

Thanks are due to the British Dyestuffs Corporation, Ltd., who very kindly supplied the pyrethrum flowers and other materials necessary, and also extracted the crude active principles, thus providing the requisite materials for the 1929 trials.

Acknowledgment must also be made to Mr. G. Marshall, Breinton, Hereford, for facilities in carrying out the Loganberry trials, whilst Mr. A. H. Hiller of Dunnington Heath, near Evesham, spared no trouble to make the Raspberry trial of 1929 a success. The writer also wishes to thank Mr. J. C. F. Fryer and Mr. F. Tutin for very helpful suggestions and assistance and encouragement throughout the work.

Bibliography.

(1) Theobald, F. V. "The Insect and Other Allied Pests of Fruit."

(2) Warburton, C. *Ann. Rept. for* 1913 *of the Zoologist. Jnl. Roy. Agric. Soc., Vol.* 74, 1914, *pp.* 368-388.

(3) Lees, A. H. *Ann. Rept. Agric. and Hort. Res. Stat., Long Ashton,* 1917, *pp.* 35-36.

(4) Do. *Ann. Rept. Agric. and Hort. Res. Stat., Long Ashton,* 1919, *pp.* 48-49.

(5) Lees, A. H. and Peren, G. S. *Ann. Rept. Agric. and Hort. Res. Stat., Long Ashton,* 1920, *pp.* 74-77.

(6) Do. *Ann. Rept. Agric. and Hort. Res. Stat., Long Ashton.* 1921, *pp.* 67-69.

(7) Peren, G. S. *Ann. Rept. Agric. and Hort. Res. Stat., Long Ashton,* 1922, *pp.* 62-68.

(8) Do. *Jnl. of Pomology and Hort. Sci I I I,* 1, 1922, *pp.* 62-65.

(9) Ministry of Agriculture and Fisheries, *Leaflet No.* 139, 1925, *p.* 5.

(10) Tutin, F. *Ann. Rept. Agric. and Hort. Res. Stat., Long Ashton,* 1928, *pp.* 96-102.

(11) Fryer, J. C. F., Tattersfield, F. and Gimingham, C. T. *Annals. of Appl. Biol. X V,* 1928, *pp.* 423-445.

(12) Martin, H. "The Scientific Principles of Plant Protection." 1928, *p.* 127.

(13) Austin, M. and Theobald, F. V. *Jnl. S. East. Agric. Coll., Wye, Kent. No.* 25, *July,* 1928, *pp.* 59-67.

(14) Austin, M. *Op. Cit., No.* 26, *July,* 1929, *pp.* 124-135.

EXPERIMENTS ON THE CONTROL OF PEAR MIDGE (Contarinia pyrivora).

Progress Report.

By L. N. Staniland and C. L. Walton.

Introduction.

Work on the control of this well-known pest has been in progress since 1926, and whilst giving promise of success in certain directions, has been sadly hampered by persistent loss of crop through frost damage, during the past three seasons, and especially in 1929, when trials designed to give more or less conclusive results were entirely vitiated.

A brief account of the lines of work so far attempted is as follows. In the first instance the junior author carried out trials with attractants, etc., in collaboration with Mr. A. H. Lees, late of this Station. Following a discussion in 1926, the senior author initiated several small scale trials in N. Wales and the junior a much more extensive series in the Bristol Province. In 1928, following the appointment of the senior writer to Long Ashton, joint work was undertaken in that year, and again in 1929. The lines followed have been (*a*) experiments with attractants, (*b*) with calcium cyanide and (*c*) with a nicotine spray and to a smaller extent, (*d*) removal of surface soil and (*e*) tar oil washes applied to soil.

Life History of the Pest.

"The adult midges hatch out in April as the pear blossoms show the first white petals and they continue on the wing until the second week in May" (1).

The females lay their eggs in the blossoms, often before they open, and the larvae on hatching commence to feed, and cause at first, a rapid and swollen growth of fruits the majority of which eventually fall. By the beginning of June most of the maggots are mature, and leaving the decaying fruitlets pupate just below the soil surface; although some may remain and pupate within the fruitlets.

(1) Theobald, F. V. "Insect Pests of Fruit," p. 345, 1909.

Experiments with Attractants—1926 *and* 1927.

In view of the fact that Amyl Acetate (commonly known as Pear Essence) possesses a strong odour approaching that of the fruit, it was thought that other odoriferous substances might prove attractive to the Pear Midge when in the winged state. Accordingly sixteen essential oils and other organic compounds were selected for test.

The experiment was carried out in an infested orchard of William's Bon Chretien pears, near Evesham, in the spring of 1926. The method employed was to stir the attractant into a banding grease, which had been heated until it was semi-liquid. Enough of each of the selected substances was then added to create a distinct odour. This somewhat rough method seemed sufficient for preliminary tests, having regard to the fact that there were no available data as to the attractiveness or otherwise of the substances used. The various greases were then spread upon both sides of wooden boards 18 inches square, and hung up in the trees. In order to avoid the possibility of any two substances competing in the attraction of midges from any given spot, groups of several trees were left untreated between each board. The experiment was made when the blossom was just showing white.

When the attacked fruitlets had fallen the boards were removed and examined and it was found that a very large variety of insects had been caught. The condition of the midges caught was such that it was impossible to obtain figures as to the relative numbers of the two sexes, but the following table gives the substances used, together with the number of midges caught, and an indication of the proportion to other insects.

Order in Plantation.	Pear Midge.	Pear Midge as Proportion of Total Catch.
Fennel Oil	27	High
Thyme Oil	1	Low
Amyl Acetate	1	Low
Clove Oil	42	Mod.
Cedar Oil	11	Mod.
Geranium Oil	1	Low
Verbena Oil	3	Low
Rosemary Oil	2	Low
Nitro Benzene	50	High
Paraffin (Commercial Sample) ..	4	Low-Mod.
Orange Oil	3	Low
Acetaldehyde	8	Low-Mod.
Peppermint Oil	1	Low
Lemon Oil	0	Low
Benzene	1	Low
Carraway Oil	0	Low
Total ..	155	

It is interesting to note that Amyl Acetate showed no attractiveness for the Pear Midge, whilst Nitrobenzene, Clove and Fennel in that order were definitely attractive, and Cedar to a less extent. Further, the relative numbers of Pear Midge as a proportion of the total number of insects caught were high in the case of Nitrobenzene and Fennel. With the possible exception of Aldehyde, none of the other substances used proved attractive.

No reduction in the number of attacked fruitlets was observable, even on those trees bearing the more attractive substances, and it was not therefore considered that the method was likely to prove of practical value.

In 1927, several dozen large boards were treated with grease and nitro-benzene and hung in different trees. The crop proved to be light and practically all fruitlets were attacked by Midge.

Experiments with Calcium Cyanide.
1926-27.

Experiments in the Bristol Province in this season were completely spoiled by frost.

In N. Wales, however, some preliminary trials were successful. These were carried out in gardens at (1) The College Farm, Aber, and (2) Madryn Farm Institute, nr. Pwllheli and (3) nr. Llangaffo, Anglesey. In all these calcium cyanide was dug in to a depth of 4 inches beneath trees and bushes, all of which had been heavily infested for years. The rates used were $\frac{1}{2}$ oz., 1 oz. and 2 oz. per square yard, applied in most cases to groups of trees, with untreated trees as controls. The soil was in most cases of a light nature. The controls showed infestations up to 38% whilst the treated trees bore crops free from injury, except one large standard which on the 23rd June, 1927, bore 166 sound fruits and 7 attacked by Midge, and two in Anglesey where there was dense old grass turf and where the treatment failed to have effect.*

1927-28.

In 1927-28 a trial near Evesham was ruined owing to a mishap, and another near Cheltenham by frost.

At the Reddings, near Cheltenham, however, some interesting figures were obtained. At this centre 6 very large standard trees of Beurre Superfin, growing in a very heavy soil, were treated, two at the rate of $\frac{1}{2}$ oz. and four at 1 oz. per square yard, on 27th October,

* We must express our thanks to the Horticultural Superintendents of Anglesey, Flint and Caernarvon, for assistance in connection with this work and for reports on further successful trials during 1927-28.

1927. Two were left untreated. These trees were 40 years old, and had been infested for about 25 years, as much as four-fifths of the crop being lost in some recent years. At the time the calcium cyanide was dug in, the soil was damp after recent rain, and thick with dead leaves. The trees cropped well in 1928, and were examined on June 18th. The fruitlets were counted as random samples, from top to lower branches, by means of ladders.

For the two control trees the infestation was 22% of fruitlets (930 fruitlets examined).

The two trees under the ½ oz. treatment showed an infestation of 8% (990 fruitlets examined), and the four trees under the 1 oz. treatment 7% (988 fruitlets examined).

It may be noted that one of the trees at 1 oz. rate was somewhat isolated, and on this no affected fruitlets were noted out of 117 examined. This tree was smaller than the rest. The other trees were relatively close together, in one case a control tree touching one of the 1 oz. trees. Under these circumstances the figures seem to us all the more interesting.

The treatment is being continued by the owner, and will be further observed.

1928-29.

Considerable field trials near Evesham and Cheltenham were entirely ruined by spring frosts.

Experiments with a Nicotine Spray.

As a result of a statement by a well-known grower, that he had obtained good results from a Nicotine + Lead Arsenate spray, trials were carried out in 1928 and 1929, nicotine alone being used.

1928.

Four large trees of "Williams" pears at The Reddings, near Cheltenham, were sprayed with Nicotine at the rate of 6 ozs. per 100 gallons of water, and the requisite amount of soft soap, using about 3½ gallons per tree. The weather was calm and overcast following heavy rain, and the subsequent weather was adverse. The trees were just past the full flowering stage. The following figures were obtained from a count on 18th June, 1928. The crop being very light, all fruits were counted.

Controls—49 fruits affected from a total of 141 — 34.8%

Sprayed—20 fruits affected from a total of 211 — 9.5%

1929.

Similar trials were put down at three centres, the whole comprising between 50 and 60 trees.

In one of these centres the crop was totally destroyed by frost, whilst in another only odd fruits remained.

At the third centre, however, an interesting circumstance arose. This trial was in a heavily infested orchard near Newnham-on-Severn, which being close to the tidal portion of the Severn, is, as a rule, very free from late frosts. The infestation had been high (on several varieties) for some years. Nicotine spraying was carried out on April 21st. This date was relatively late owing to the fact that the flowering date for Conference* (the variety sprayed) at this place was a fortnight later than usual. This was due, in the opinion of the grower, to the severity of the preceding winter. At the time of spraying—a fine warm day—no Midges were to be seen, and we surmised that the insects might have hatched about the usual flowering date, and died before the flowers actually opened. A full crop of pears followed, and we were unable to find a single infested fruitlet.

The grower states that a similar sequence followed an unusually hard winter some 10 years before (but cannot verify the date) the infestation gradually increasing in the following years.

Experiments with Tar Oil Washes.

In September, 1926, a 20% solution of a tar oil wash was applied to the soil below 12 trees in an infested grass orchard of standard pears, the variety being Williams Bon Chretien. The ground around the trees was thoroughly soaked, and the grass became reddish brown, and appeared dead.

In the following season, there was a fairly heavy set of fruit, but very few fruitlets remained unattacked. The grass had recovered and had grown well, more particularly the coarser varieties. The application was made in winter to standard trees, and the trial was on a small scale. Control trees were severely attacked.

A trial, using two proprietary tar oil washes at 10% strength was put down in 1929, but frost destroyed the blossom on all the trees.

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* It may be noted that C. H. Hooper gives April 10th as the full flowering date for Conference in the Maidstone district. (Gardeners' Chronicle, Apl. 20th, 1929, p. 298).

Control of the Midge by Removal of Surface Soil.

The correctness of the widely expressed opinion that this pest can be controlled by the removal of soil from beneath the trees is illustrated by an observation near Gloucester. Three "Williams" trees, all about 18 feet in height, and each covering about 100 square feet of ground, were very severely infested, the entire crop being ruined in 1925.

During the winter 1925-26 all soil was removed from beneath two of these trees, to a depth of 4 inches, and the operation was commenced on the third tree, but not completed. The land is light and sandy. In 1926 and 1927 the crops failed through frost. When examined on the 13th June, 1928, the two trees treated in 1925-26 had 350 sound fruits, and one attacked by midge larvae. On the third (incomplete treatment), a moderately heavy crop was severely attacked.

Conclusions.

(1) Of the wide variety of volatile organic substances tested, Nitro-benzene, and to a lesser degree Oil of Cloves and Oil of Fennel, showed considerable attractant properties for Pear Midge, but they did not appear to be of practical control value against this pest.

(2) Calcium cyanide worked into the soil at the rates of $\frac{1}{2}$, 1 and 2 oz. per square yard to a depth of four inches, and applied in June, effected a complete control in the case of light garden soil, and applied to heavy wet soil in October, resulted in a considerable reduction in infestation. A rate of $\frac{1}{2}$ oz. per square yard appeared to be the most suitable quantity to apply.

(3) Nicotine and Soft Soap applied to the open blossoms effected a marked reduction in attack.

(4) The removal of soil from beneath affected trees, to a depth of four inches, resulted in a control of the Midge.

(5) Tar Oil solutions applied to grass orchards, failed to control the pest.

INVESTIGATIONS ON THE FUNGICIDAL ACTION OF SULPHUR.

IV.—Third Progress Report.

By B. T. P. Barker.

Introduction.

The first and second progress reports on this subject were published in the Annual Reports of this Station for 1919 (3) and 1927 (4) respectively. The fundamental conclusions reached during the stage of the investigations covered by those two papers were (*a*) that, as used in practice, sulphur before it becomes active fungicidally must be in contact with a sulphur-reactive living organism and (*b*) that, when such contact has been established, a chemical reaction occurs, resulting in the formation of a gaseous sulphur compound giving the characteristic reactions of hydrogen sulphide. Supplementing these conclusions, Marsh (7), in the third paper of the series, has shown the latter substance to possess fungicidal properties of a high order.

The earlier results also appeared to show that contact between living organisms and sulphur can be established by the dispersion through space of the latter in " particulate " form. This view has been contested by Goodwin and Martin (5). Since the present paper deals solely with the aspect of the problem concerned with the behaviour of sulphur after it reaches the living organism and related questions, it is outside its scope to include a detailed reply to their article. This will appear elsewhere in due course. It must suffice here to point out that their results and conclusions were based upon experiments in which entirely different conditions to those used in the Long Ashton experiments obtained, and that they have apparently not attempted to confirm under similar conditions the observations made at this Station which led to the formulation of the hypothesis that sulphur travels through space in " particulate " form.

During the past three years the investigations at Long Ashton have been almost entirely confined to the problem of the nature of the interaction between the living organism and sulphur. The earlier publications have shown that when a particle of sulphur

is in contact with the living spore or mycelium of certain fungi, *e.g. Sclerotinia fructigena*, reactions indicative of the formation of sulphuretted hydrogen can be obtained. With other fungi, *e.g. Botrytis cinerea*, no interaction has been observed. Similarly, when flowers of sulphur are dusted on the stomatal surface of leaves of certain plants, *e.g.* the strawberry, a postive result can be obtained with the lead acetate test for hydrogen sulphide. (See Plate I). Other plants have given negative results. Further, even with sulphur-reactive plants, all leaves do not respond with equal activity. The youngest give the most intense result. With increasing age of leaves the reaction becomes less and old leaves fail to give any positive test. The most obvious conclusion from these initial results is that the living organism in certain cases and usually under active growth conditions reacts with sulphur by means of a reducing substance, which is a product of the metabolism of the cell.

The formation of hydrogen sulphide as the result of intimate contact between the living organism and sulphur has been recorded by various earlier investigators. To mention two cases of a diverse character, firstly, Polacci (9) has shown that lead acetate paper became blackened when suspended in a closed vessel containing a bunch of ripe grapes which had been sprinkled with flowers of sulphur. Secondly, Babo and Mach (2) have recorded the formation of hydrogen sulphide after the addition of flowers of sulphur to a fermenting sugar solution. Their explanation of the action was that the alcohol in the solution dissolved a part of the sulphur, which then was absorbed by the living yeast cells in the dissolved form, utilised in their metabolism and ultimately excreted as hydrogen sulphide. In view of the comparatively slight solubility of sulphur in absolute alcohol it may be doubted if the relatively low strength of alcohol in the fermenting liquor is sufficient to bring about directly any solution of the sulphur. Later in this paper the interaction of sulphur and living yeast cells will be further considered, when it will be shown that for other reasons also the hypothesis of Babo and Mach appears untenable. In fact, all the evidence available in the earlier stages of the present investigation pointed to the probability that the reaction between the living organism, whether fungus or higher plant, and sulphur is extracellular—or, at least, at the surface of the living cell—and not intracellular and the more recent work has been based on that assumption.

From that conclusion it has followed that the interaction is likely to be due to a substance, or substances, emerging from the living organism and capable of direct and rapid action on sulphur at ordinary temperatures, such action being either of an immediate

simple reducing character leading to the direct production of hydrogen sulphide or of a more complex order in which the latter substance appears as a final product after one or more intermediate reactions.

The objectives of the main research since the last progress report have therefore been (*a*) the identification of the reducing substance or substances formed by the living organism and (*b*) the exact nature of the action which culminates in the reduction of sulphur to a sulphide. Under more straightforward conditions the attainment of the former objective would naturally have preceded investigation of the latter. In this particular case, however, concurrent investigation of the two problems soon became a necessity. No success attended the attempts to isolate the reducing factor or even to secure any form of preparation of it in reasonable strength apart from the living organism. Consequently its identity remained speculative and some clue to it had to be sought by means of investigations of its reactions. Neither objective has yet been gained completely, but a considerable amount of new and suggestive information bearing on both has been secured and a part of it is included in the following sections of the present progress report.

The Occurrence of the Sulphur-Reducing Factor in Living Plants.

The second progress report recorded the reduction of sulphur by the leaves of plants belonging to natural orders as distinct as the *Rosaceae*, *Ribesoideae*, and *Gramineae*. Mention was also made therein of the diverse behaviour of various fungi in this respect. Wiltshire (3) and Marsh (7) have dealt with this in greater detail.

This property, having been shown to be common to members of both flowering plants and fungi, is presumably widely distributed throughout the plant kingdom. To test this view further trials were made on a considerable number of plants representative of a very wide range. The procedure adopted with the higher plants was to sprinkle flowers of sulphur on both surfaces of leaves of the plant and clamp filter paper moistened with basic lead acetate solution on the sulphured leaves. In the case of the micro-organisms the procedure varied : in some instances hanging drop cultures of water containing the spores and sulphur were used and inhibition of germination was taken as a positive result, and in others sulphur was sprinkled on a mass culture and moist lead acetate paper lightly applied. In the case of the yeasts sulphur was added to actively fermenting cultures in sugar solution and the evolved gas tested with lead acetate paper.

Table I shows the results obtained from individual flowering plants.

TABLE I.

Lead Acetate Paper Coloured Black or Brown.

Anchusa italica	Delphinium	Rose
Apple	Evening Primrose	Strawberry
Aquilegia	Gooseberry	Sweet Pea
Black Currant	Michaelmas Daisy	Thistle
Bryony	Raspberry	Tropœolum

Lead Acetate Paper Coloured Faintly Brown, but Sulphide Formation Doubtful.

Asparagus	Iris sibirica	Runner Bean
Balm	Lettuce	Tomato
Groundsel	Pear	Weigelia

Lead Acetate Paper Uncoloured.

Antirrhinum	Holly	Phlox
Bean, French	Hop	Polyanthus
Brussel Sprout	Iris (Flag)	Potato
Carrot	Jerusalem Artichoke	Sage
Cauliflower	Kale	Sonchus
Celery	Laurel	Tamarisk
Chrysanthemum	Leek	Thuja Lobbi
Choisya ternata	Lilac	Thyme
Convolvulus	Marjoram	Turnip
Dahlia	Montbretia	Wallflower
Egg Plant	Nicotiana	Willow
Galega	Nepeta Mussini	
Golden Privet	Parsley	

Table II shows the corresponding results obtained from some of the lower plants.

TABLE II.

Lead Acetate Paper Coloured Black or Brown.

Fungi.	*Penicillium sp.*	*Saccharomyces ellipsoideus* (6 varieties).
	Physalospora miyabeana.	*Sclerotinia cinerea.*
	Podosphaera leucotricha.	*Sclerotinia fructigena.*
	Saccharomyces anomalus.	*Sclerotinia trifoliorum.*
	Saccharomyces cerevisiae.	*Stereum purpureum.*
Algae.	*Pleurococcus sp.*	*Ulothrix sp.*
Bryophyta.	*Polytrichum sp.*	*Marchantia sp.*

Lead Acetate Paper Uncoloured.

Fungi.	*Alternaria sp.*	*Rhizopus Delemar.*
	Botrytis cinerea.	*Rhizopus sp.*
	Fusarium martii, var. *phaseoli.*	

The author is indebted to Messrs. F. C. Lewis, F. E. Maltby and R. W. Marsh for their assistance in making these tests.

As regards the means by which the living organism effects this reduction, the term "reducing factor" is applied throughout this paper in view of the present incomplete knowledge of its nature.

It must not be assumed that all plants which yielded negative results do not produce the reducing factor. The majority of the tests with the higher plants were made in the month of September, a time of year when even actively reducing plants like the strawberry begin to show weaker reduction and not infrequently fail to yield conclusive results. However, even without that qualification, a sufficient number of positive results was obtained to prove that the reducing factor is not limited to any particular family or class of plants, and that its occurrence throughout the plant kingdom is widespread.

From the manner in which the above tests were made, the positive results secured were obtained by mere contact between the sulphur and the living plant. In the case of the higher plants, only the stomatal surfaces of the leaves showed reducing power. It is difficult to conceive that under the conditions of experiment the reduction occurred in consequence of any sulphur actually reaching the protoplast: at the most such contact as existed was between the cell wall and the sulphur, and in hanging drop cultures actual contact of that kind was not always visible under the microscope. Hence the conclusions that the reaction is extracellular and not intracellular and that the reducing factor has passed outside the protoplast and has diffused into the cell wall and possibly beyond.

There remains the possibility that some, at least, of the plants which have given negative results may also contain the reducing factor within the cell and that in these cases it may be held back by the protoplast.

Some evidence pointing in that direction has been obtained from tests carried out with several fruits and vegetables. Where fruits were used, portions of the inner tissues were sprinkled with flowers of sulphur and well ground in a mortar. A small sample of the pulped mass was then transferred to a test tube, distilled water added and the contents of the tube boiled after covering the mouth of the tube with filter paper moistened with basic lead acetate solution. The parts of the vegetables tested were storage organs, as, for example, the tubers of the potato and Jerusalem artichoke and the roots of the carrot, turnip, parsnip and salsafy. The procedure was similar to that used for the fruits, portions of the inner tissues only being taken. In several instances, notably with the Jerusalem artichoke and apple, the lead acetate test papers showed brown colourations of various depths of colour, indicating the

formation of lead sulphide. Sometimes, when no colour was produced or only a faint tint appeared, a more positive result was obtained after the addition of a few drops of dilute sulphuric acid to the sample under test before heating. This effect of acidification suggests the possibility of the existence of an intermediate sulphur compound, a point which will be considered in more detail later. Generally speaking, production of the sulphide was inclined to be variable in confirmatory tests whether the material was acidulated or not. This is not surprising considering the relatively crude form of test, for oxidising as well as reducing factors may be expected to be present in the crushed tissues and interfere with the reduction of the sulphur: in fact, it is possible that oxidation of some of the sulphur may occur concurrently with reduction and reaction between the oxidised and reduced derivatives follow.

The work recorded in this section of the paper is regarded as of a preliminary character only. More exhaustive experiments with the internal tissues of plants are necessary before the results can be regarded as fully established. So far other sides of the investigation have claimed more attention, but some preliminary information on the points which have just been discussed was desired for possible assistance in those investigations.

The Sulphur-Reducing Factor of Yeasts.

One of the chief difficulties experienced in investigating the nature of the sulphur-reducing factor and its action has been the supply of adequate material. During the earlier part of the work leaves of strawberry plants were used almost exclusively since, as stated in the last progress report (4), these after sulphuring gave more decisive reactions with lead acetate paper than any other material tested up to that time. Such material, however, was subject to the serious drawback that the supply was seasonal. Only young actively-growing leaves show the reducing power strongly enough to be of service and these can only be obtained during a relatively short period of the year—a period, too, when many other duties have prior claim on the author's time.

Recently, however, the author decided to examine the yeast plant as a source of supply. In studying the yeast *Saccharomyces anomalus*, (*Willia anomala*), in 1900, he discovered that the addition of flowers of sulphur to sugar solutions in course of active fermentation by pure cultures of this yeast was followed by a copious evolution of sulphuretted hydrogen, easily identifiable both by smell and by the lead acetate test. On repeating these old experiments recently it was evident that this yeast offered a

much more satisfactory opportunity of investigating the sulphur-reducing factor of plants than the strawberry leaf. Both in respect of intensity of the reaction and continuous supply of material, capable of extension to any amount and at short notice as required, it possessed a marked advantage.

After a few preliminary trials it was found that this yeast caused certain complications in the work owing to its outstanding characteristic of the production of conspicuous quantities of ethyl acetate and other volatile esters. It was decided, therefore, to test the action of other yeasts in a similar way in the hope of finding one equally efficient which did not present that drawback. Several pure cultures of yeasts used in the Cider Department of the Station were accordingly tested, all of which gave positive results and some as good as the *anomalus* species. Apparently, therefore, the sulphur-reducing property is widely distributed throughout the yeast family.

This conclusion then led to the idea that pressed yeast might serve the purpose in a most convenient way, unlimited quantities being readily available at any time. The three following tests quickly demonstrated its suitability.

(1) A small fragment of pressed yeast was shaken up with water in a flask until the individual cells were separated, flowers of sulphur then added and the flask closed with a cork after lead acetate paper had been suspended above the liquid. Within two minutes the lead sulphide coloration began to appear on the paper.

(2) A small fragment of the pressed yeast was placed in a test tube with water and flowers of sulphur and the liquid at once boiled. A dark lead sulphide stain was formed immediately on lead acetate paper placed over the mouth of the tube.

The same experiment was repeated with a sample of the yeast which had been repeatedly and thoroughly washed with distilled water. The result was similar, proving that no soluble foreign body adhering to the surface of the yeast was responsible for the reduction of the sulphur.

(3) Sulphur was dusted over the surface of a mass of the pressed yeast, which was then wrapped in filter paper moistened with basic lead-acetate solution. Within a few minutes the paper showed signs of discolouration and very soon became blackened owing to the formation of lead sulphide.

The latter test corresponded with the standard strawberry leaf test used earlier in the course of these investigations and the result showed the yeast to be more active as a reducing agent than even the youngest and most vigorous strawberry leaves.

Control experiments with yeast without the added sulphur gave negative results.

In the most recent work, therefore, pressed yeast has been substituted for strawberry foliage as a source of supply of the reducing factor. Until the chemical identity of the latter has been discovered, there can be no proof that it is the same for both the yeast and the strawberry. On the other hand, its behaviour in the two cases is so closely parallel that it is difficult to conceive that the chemical identities can be widely dissimilar : the fact that both reduce sulphur in the cold with great rapidity is in itself strong presumptive evidence of close class relationship, if not of actual identity. Hence, the investigation is proceeding at the moment mainly with yeast as the source of supply of the reducing factor on the assumption that the latter is of the same general chemical character for all plants.

Some Other Forms of Reduction by the Living Plant.

The demonstration of sulphur reduction by mere contact between the living plant and sulphur shown by the cases which have been already cited has suggested that corroborative evidence of this reducing property of the organism under the conditions of the trials might be obtainable by the use of other more readily reducible substances in the place of sulphur. Further, such substances might furnish a chance of gaining new information of the nature of the reducing factor and its mode of action.

The existence of a reducing mechanism within the living plant is well known, but that has been regarded as intracellular in action. Various investigators have also noted that under certain conditions various substances in solution, including sometimes reducing agents, diffuse or are exuded from living cells. Arens (1), for instance, has recently described observations on leaf exudates escaping from the stomatal openings of leaves : these exudates contained complex organic compounds and the presence of phosphatides was demonstrated. No references, however, have been found by the author to any reducing action on sulphur on the part of such exudates.

It was decided therefore to secure, if possible, confirmatory evidence of the emergence of reducing substances from plants which had already given a positive result in the earlier stages of the sulphur work.

The strawberry was the plant selected in the first instance on account of its activity with sulphur. The reducible substances taken as test examples were potassium iodate, ferric chloride and silver nitrate. Different procedure was necessary with each substance in view of their diverse characters. The method of test and the results in the respective cases were as follows.

Potassium iodate. This substance in powdered form was dusted on both upper and lower surfaces of young actively growing strawberry leaves and the latter were then enclosed in a wrapping of filter paper moistened with a dilute aqueous starch solution. The filter paper was held tightly adpressed to both leaf surfaces between stiff cardboard pads secured by spring clips. The experiment was thus similar in form to the earlier ones with sulphur and lead acetate paper. After the test had been in progress for an hour, the filter paper in contact with the lower leaf surfaces showed the characteristic blue-black colour indicative of the formation of free iodine and the coloured area corresponded roughly with the leaf surface. No coloration appeared on the starch paper in contact with the upper leaf surfaces.

This result thus shows that at the lower surface reduction of the iodate to iodide had occurred, the latter reacting with a part of the iodate to form free iodine, which in turn reacted with the starch on the filter paper to give the blue-black starch-iodine compound. The absence of coloration on the paper adpressed to the upper leaf surfaces indicated that no reduction of the iodate had occurred on that side of the leaves.

Ferric Chloride. This substance cannot be applied directly to leaves without injury to the latter. Hence, the method of test used in the previous case required modification in this instance. A satisfactory method was eventually obtained by coating glass plates with a film of gelatine containing a small percentage of ferric chloride and inserting young strawberry leaves between pairs of such plates with the gelatine-covered side always next the leaf surface. These pairs of plates were clamped by spring clips to hold the gelatine layers in close contact with both sides of the leaves. After several hours of contact the plates were removed and "developed," by immersion in a dilute aqueous solution of potassium ferricyanide. In due course there appeared on the gelatine films which had been in contact with the lower surfaces of the leaves a dark blue area corresponding in outline with that of the leaf. The films exposed to the upper leaf surfaces showed no such coloration.

The dark blue colour obtained with the former was due to the formation of ferrous ferricyanide and showed that a part of the ferric chloride in the film in contact with the lower leaf surface had

been reduced to the ferrous condition. The absence of such colour in the films exposed to the upper leaf surface indicated absence of reduction in that region.

Thus with the series of tests of substantially the same form with sulphur, potassium iodate, and ferric chloride respectively there was clear evidence of the presence of a reducing factor at the lower leaf surfaces.

Silver Nitrate. As with ferric chloride, this substance cannot be directly applied to leaves on account of the injury to the latter. The gelatine film method used for the ferric chloride tests could not however, be satisfactorily used in this case on account of the instability of the silver salt. Fortunately, by the time this part of the investigation had been reached, sufficient progress with another part to be described presently had been reached to make it possible to try the silver reduction test in an entirely different manner.

The following procedure was used. Young strawberry leaves were immersed momentarily in 90 per cent. alcohol to wet thoroughly both upper and lower surfaces. The foliage was immediately washed free from alcohol as quickly as possible in a stream of running water and then transferred without delay into a beaker containing the least possible distilled water to ensure complete immersion. It was left there 10-15 minutes to enable the water to dissolve any solutes. The clear liquor was then decanted, filtered and used for the tests. The addition of a few drops of ammoniacal silver nitrate solution to a portion of this filtrate resulted in the blackening of the liquor, indicating the production of reduced silver.

When a corresponding test was made with leaves which were not treated preliminarily with alcohol, no reduction of silver was obtained.

The only difference in the two cases, so far as the leaves themselves were concerned, appeared to be that after the preliminary treatment with alcohol their lower surfaces were readily wettable with the water used subsequently for solvent purposes, whereas in the absence of the alcohol treatment the water never actually wetted the lower surfaces and thus had no opportunity of dissolving any solutes which might be present there.

The conclusions drawn from these tests were, firstly, that a substance could be dissolved or washed from the leaves with water in the course of standing some minutes, the substance having the power of reducing ammoniacal silver nitrate and, secondly, that it

was only taken up by the digesting water when the lower leaf surfaces were wettable, and therefore presumably was derived solely from those surfaces, since the upper surfaces were readily wetted with or without the preliminary treatment with alcohol.

Other Reductions. There is thus now a considerable amount of confirmatory evidence supporting the view that the leaves of certain of the higher plants exude at their surfaces on the stomatal side a reducing factor which is capable of the reduction of substances such as sulphur and the reducible compounds just mentioned *in the cold.* In other words, such leaf exudations contain a reducing factor of a very active character.

That the sulphur-reducing fungi also exude a similar, if not identical, factor is a logical corollary. Proof has now been secured in the case of the three chemicals referred to in this section, so far as the yeast plant is concerned.

A simpler method of test in this connection was possible. The procedure in all cases was simply to add a small quantity of the reducible chemical under trial to an emulsion of yeast cells suspended in water and to test, after an appropriate period of standing, for the presence of the reduced derivatives.

Potassium iodate solution after standing for an hour in contact with living yeast cells showed the presence of free iodine.

Ferric chloride solution under similar conditions showed the presence of a ferrous compound on testing with potassium ferricyanide.

Silver nitrate solution quickly gave evidence of the formation of reduced silver when in contact with a suspension of yeast cells.

In addition, solutions of methylene blue were decolorised on standing after the addition of yeast, reduction of the methylene blue being thus indicated.

In one important respect these tests with yeasts differed from those with the strawberry leaves. The latter remained alive throughout the duration of the tests, whereas the yeast cells, being in direct contact with solutions of highly toxic salts, were presumably killed during the course of the tests. There was thus a chance that in the latter case there may have diffused from the closed cells reducing substances which normally are not exuded from the cells while living. The further work described later in this paper indicates, however, that the main point at issue may not be materially affected by the death of the cells.

The Reducing Factor in Relation to the Living Plant.

Hitherto investigations on the subject of the fungicidal action of sulphur have laid stress on the importance of contact actual or, at least, close proximity between the sulphur applied for fungicidal purposes and the living organism. Thus Salmon (10) in his studies with the Hop Mildew has noted by microscopical observations that collapse of the conidia followed only when a fragment of sulphur was placed upon a conidium. In the earlier investigations at this Station Wiltshire (3) showed that in hanging drop cultures of water containing a suspension of conidia of *Sclerotinia fructigena* and flowers of sulphur the germination of the conidia was inhibited when the cells were in contact, or almost in contact with a particle of sulphur, while conidia in the upper part of the drop well clear of the sulphur layer in the lower part germinated with some freedom. In another experiment he found that conidia of the same fungus sown on the surface of a plate of agar germinated freely except in certain areas in the centre of which in each case a small quantity of flowers of sulphur had been placed on the agar. In those areas no conidial germination occurred in the immediate vicinity of the sulphur: the further the conidia in those "zones of influence" were situated from the sulphur mass, the less was their germination affected and the longer were the germ tubes produced.

Thus, while there is clear evidence that actual contact between sulphur and a sulphur-sensitive fungus results in a toxic action on the latter, there is also some ground for concluding that interaction between the two can take place without actual contact provided that the intervening distance is not too great. This conclusion implies the view that either from the sulphur or the organism there diffuses some substance which brings about the reaction resulting ultimately in the production of the toxic hydrogen sulphide. If the diffusion is from the sulphur it must be in the "particulate" form or as vapour, since the earlier work has failed to show that any sulphur compound in the necessary quantity to give toxic results is evolved. The earlier part of this paper, however, has attempted to show that the organism itself is responsible for the production of a reducing factor and the special point for consideration here is whether or not this factor can remain effective apart from the cell. Reasons have already been given for the view that its action is extracellular and not intracellular.

The experiments described in the previous section of this paper in connection with the reduction of silver nitrate by water in which strawberry leaves have been immersed, afford reason for the view that the reducing factor can be washed or leached from the foliage and that this factor accordingly can exist apart from the living

organism. On the other hand, the following experiment, repeated many times with minor variations of detail, seems to show that the removal of the reducing factor from the organism is not so simple as might appear. Yeast cells, shown by preliminary tests to be active reducers of sulphur, were suspended in water and the liquor filtered through a porous porcelain filter. The yeast-free filtrate was then shaken well with sulphur and tested for the presence of hydrogen sulphide. Not the slightest trace of blackening or discoloration appeared on the lead acetate paper used for the test, whether the liquid was unboiled or boiled or acidified with a few drops of sulphuric acid both in its cool and heated states. The reducing factor therefore cannot pass from the culture of living cells through a porous porcelain filter. When ordinary hardened Swedish filter paper was used instead of the porous porcelain as a filter, the result was similar. Corresponding negative results were obtained when in the place of a suspension of pressed yeast cells in water an actively growing culture of yeast in a nutrient sugar solution was tested similarly.

When, however, the yeast suspension in water was boiled for a few minutes to ensure the killing of all the cells, the filtrate from the boiled liquor possessed active sulphur-reducing properties in its freshly prepared condition. On the filtrate being shaken for a few minutes with flowers of sulphur and afterwards boiled, copious evolution of sulphuretted hydrogen was proved by the lead acetate paper test. After standing 18 hours the filtrate similarly treated gave no sign of production of hydrogen sulphide. Also when the filtrate was shaken with sulphur in the cold immediately after filtration and then placed in a closed glass vessel, no signs of the formation of hydrogen sulphide were shown by lead acetate paper suspended above the liquid.

While from these experiments it seems that the killing of the yeast cells may be necessary to remove the reducing factor from the organism, such drastic treatment is not required with the strawberry leaf. The method of obtaining a reducing aqueous extract from the leaf has already been described in connection with the experiments on silver nitrate. Leaves so treated showed no obvious signs of injury after 24 hours immersion in the leaching water. The latter, in addition to giving the silver reduction reaction as described, showed definite reducing properties with sulphur. In the cold, even after long standing, no production of hydrogen sulphide has been observed; but, when the freshly prepared leaf extract was boiled immediately after the addition of sulphur and a few drops of sulphuric acid then also added, renewed boiling gave the lead acetate paper test for the sulphide.

Certain precautions necessary to observe in connection with this test should be mentioned. They apply to all cases where sulphur suspended in aqueous liquids is heated to boiling point. The usual form of the test for hydrogen sulphide used in the experiments has been to heat the sulphured liquid in a test tube with the mouth of the tube completely covered with a piece of basic lead acetate paper held tightly over it. The heating was continued until the liquid boiled and steam just began to pass through the paper. Under those conditions sulphur and water boiled together gave no stain on the paper. If the covering paper was removed for a few seconds and then replaced and the liquid reboiled, a slight brown stain was was sometimes obtained on the paper. In no case in the course of the experiments in this investigation was a positive result for sulphur recorded unless the stain on the paper was unquestionably more intense than that referred to in the previous sentence.

It will be noted that the reductions obtained with these yeast and leaf aqueous extracts differed in some respects from those occurring when the sulphur was in contact with the living yeast or leaf as the case may be. The production of the reduced sulphur took place freely in the cold and easily detectable quantities were formed, when the reaction occurred in touch with the living organism. In the extracts the assistance of heat was necessary to bring about the reaction to an extent sufficient to colour the lead acetate paper. Also it has been mentioned that the yeast extract lost its reducing power on standing several hours. The leaf extract similarly eventually lost it, although after standing overnight only it sometimes still retained it to a diminished extent.

It does not follow that these differences imply an essential variation in the nature of the reducing action or of the reducing factor in the respective cases. When the sulphur is in direct contact with the living yeast or leaf it meets the reducing factor in an undiluted form; moreover, as previously shown, there is good reason to assume that the factor is being continuously replenished. In the extracts the supply is not renewable and is highly diluted. The loss of reducing power of the extracts on standing may well be due to oxidation or other change of the reducing factor, either by exposure to air or by the presence in the extracts of other substances which can oxidise or react with it. If this be the case, the failure to obtain with the extracts a detectable amount of reduction of sulphur in the cold but a positive result with the aid of heat can be understood.

The evidence as a whole is in favour of the view that the reducing mechanism can function apart from the organism, whether living

or dead, and that accordingly the reducing factor must be a chemical substance or mixture of substances and the reaction one of a purely chemical as distinct from a biological order.

The Nature of the Reducing Action.

The recent use of yeast in this work has made it possible to proceed with the investigation of the nature of the reducing factor under more favourable conditions than was possible when strawberry leaves had to serve as a source of supply. The substance or substances concerned have not yet been identified, but some suggestive facts as to the nature of the reaction have been obtained. These point to the reaction being more complex than a simple and direct reduction of sulphur to hydrogen sulphide.

Two examples have been mentioned incidentally in the course of the previous pages.

(*a*) In the tests with the internal tissues of fruits and vegetables such as the apple and Jerusalem artichoke when, after the tissue had been ground up in the presence of sulphur a few drops of sulphuric acid were added before heating—or it may be done after heating and then reboiling after the addition of the acid—a considerably deeper stain on the lead acetate paper was obtained than when the pulped tissue was heated without acidification.

(*b*) The strawberry leaf extract prepared as described in the previous section similarly required acidification with sulphuric acid after heating before further heating gave a sharply marked stain on the test paper.

In both these cases if the plant material was acidified with sulphuric acid before the addition of sulphur, no sulphide stain could be obtained on the test paper.

The presumption from these facts is that the sulphuring of the plant material leads to the formation of a sulphur compound, more or less resistant to heat up to 100 °C., which is decomposed on the addition of a mineral acid, with hydrogen sulphide as one of the products of decomposition. Further, the reaction between the reducing factor of the organism and sulphur is inhibited in the presence of sulphuric acid, possibly because the reducer may be basic in character and effective through its basic radicle. Some support for this suggestion may be found in the result of the following experiment. When yeast was treated in the cold with a 1 per cent. solution of caustic potash and the mixture neutralised with sulphuric acid and sulphur then added, hydrogen sulphide was evolved on heating after a further addition of sulphuric acid. The reducing factor thus retains its activity after treatment with an alkali and loses it if treated instead with dilute suphuric acid.

PLATE I.

A.

B.

The results recorded in the last paragraph appear to be significant in connection with the most recently published observations of Goodwin, Martin and Salmon (6) and Martin (8) on the fungicidal action of sulphur. These authors have found that sulphur applied in wet spray form in conjunction with a spreader varied in its fungicidal activity according to the nature of the spreader used. Its action was very marked when the spreader was alkaline, *e.g.* soft soap, lime casein and soda casein : spreaders of an acid nature, such as gelatin and saponin, inhibited the fungicidal action. Martin has suggested that this action is due primarily to hydrolysis of the sulphur, the presence of alkali serving to accelerate the hydrolysis, while "acid" spreaders conversely retard it. His reference to the analogies between the action of sulphur upon the hop powdery mildew and upon copper makes it clear that he regards the hydrolysis as a reaction between sulphur and water independent of the intervention of the living organism, although he recognises that the latter may assist by an alkaline secretion or the removal of one of the products of hydrolysis. In view, however, of the results recorded in the previous paragraph, showing the stability under alkaline conditions of the reducing factor produced by the living organism and its inhibition in the presence of sulphuric acid, the observations of these authors are readily explainable without invoking the hydrolysis hypothesis. At the same time, it must be recorded that the fungicidal action of sulphur is not inhibited in all acid media. On the contrary, the present author already has evidence that the reducing factor can survive exposure to a suitable acid medium under certain conditions, and it is intended to deal with this part of the subject in a subsequent paper.

Several additional results pointing to the existence of an intermediate sulphur compound have been obtained. The following may be mentioned :—

(*a*) Lead acetate paper placed at the mouth of a flask containing an actively fermenting sugar solution with sulphur in suspension was soon discoloured. The same solution boiled produced an intense brownish-black stain on the paper, although drops of the unboiled liquid itself poured direct on to lead acetate paper gave nothing more than the faintest stain. Also the addition of the unheated liquor to basic lead acetate solution and to water containing lead carbonate in suspension caused no discernible discoloration at the time of addition. On standing, however, those liquids developed a brownish colour and after 24 hours the originally white deposit of lead carbonate had become blackened owing to the formation of lead sulphide.

These results accord with the view of the presence of a sulphur-containing compound slowly dissociating in standing and more rapidly on heating, and yielding hydrogen sulphide as an end product.

(*b*) A number of strawberry leaves were dusted with flowers of sulphur and then placed with their petioles in water in a covered beaker in sunlight. Within the course of from a quarter to half an hour, or sometimes less, a highly characteristic smell developed. It was penetrating and sharp, somewhat aldehydic in character and not unpleasant: it has not been identified with any specific compound. Later traces of hydrogen sulphide could be detected both by smell and the lead acetate paper test. Unsulphured leaves under corresponding conditions gave nothing more than the normal odour of strawberry foliage.

(*c*) A quantity of strawberry leaves were thoroughly covered with flowers of sulphur by being lightly rolled in the hand with that substance. They were then packed as tightly as possible in a glass tube about a foot in length and an inch in diameter. The lower end of tube was plugged with a cotton-wool filter and connected with a receiver attached to a filter pump. Heavy liquid paraffin was then drawn slowly through the mass of foliage under reduced pressure. The clear paraffin extract collected in the receiver was yellow in colour, the tint varying in different tests from a pale lemon to a fairly deep orange. On heating the extract little or no hydrogen sulphide was evolved until it was acidified with a few drops of sulphuric acid: then lead acetate paper was quickly stained an intense black.

Various other liquids were tried as solvents in place of the paraffin and attempts were made to extract the coloured substance from the paraffin solution by the usual organic solvents. No really satisfactory result has yet been obtained. As soon as further supplies of young strawberry leaves in appropriate condition become available, it is hoped to investigate in a more detailed way the composition of the paraffin extract.

Control extracts of unsulphured leaves were almost colourless and failed to give any positive result with the hydrogen sulphide test.

Flowers of sulphur alone similarly treated with liquid paraffin also gave negative results.

Using sulphured slices of Jerusalem artichoke in the place of strawberry leaves under somewhat different con-

ditions, a positive result of another order was obtained. In this case the slices were simply placed in a beaker and covered with liquid paraffin. Evolution of hydrogen sulphide soon commenced at ordinary temperature and after 24 hours its presence in quantity was obvious both by smell and the lead acetate paper test. The control experiments with unsulphured slices of artichoke gave negative results.

Conclusions.

The work recorded establishes the fact that the property of sulphur reduction is widely distributed throughout the plant kingdom, examples now having been observed among Algae, Fungi, mosses and higher plants.

That the reaction takes place outside the organism and is effected by means of a substance or substances emerging from the plant appears to be proven by the rapidity of its initiation under some of the conditions of experiment and by the positive results which have been given by the aqueous extracts described in the paper.

While the reducing factor has not yet been identified,* it is known to be very active chemically, being capable of rapid reduction of such substances as potassium iodate, ferric chloride, silver nitrate, and methylene blue at ordinary temperatures as well as sulphur.

In the case of sulphur there is considerable ground for regarding the reduction as being of a more complex order than the simple conversion to hydrogen sulphide. While the latter appears as an end product, the formation of an intermediate and more complex sulphur compound, under certain conditions at any rate, is indicated by a series of varied experiments.

Whether or not this intermediate sulphur compound, which has still to be isolated and identified, possesses fungicidal properties must remain an open question until the investigation has been carried a further stage, but the end product of the reaction, hydrogen sulphide, is clearly highly toxic, as shown by Marsh (7), and is in itself sufficient to account for the fungicidal value of sulphur.

With the investigation still incomplete it would be premature here to consider at length the practical application of the results so far achieved. It is obvious, however, that the question of sulphur sprays and dusts will require consideration from a new viewpoint, centred on the production of hydrogen sulphide from the materials used. If automatic and continuous production of this substance can be achieved without injury to the crop to be protected against fungal invasion, a higher degree of disease control should be possible. The idea of activating sulphur is not new and various recent

*Since this paper has been in the press, further results obtained point to glutathione (probably identical with the hypothetical "Philothion" of de Rey-Pailhade) as the reducing factor.

attempts have been made. In them the underlying objective generally has been the oxidation of sulphur. The present work suggests that reduction, not oxidation, should be the objective and it has indicated a possible method, which will be tried at this Station during the coming season. The sulphur-reducing properties of yeasts have been referred to at some length in this paper. The incorporation of these organisms with some forms of sulphur sprays and dusts does not present any obvious serious difficulty and should result in a continuous production of hydrogen sulphide by the protective coating of sulphur on the treated plants during humid, and possibly even under dry, weather conditions. As an alternative to yeasts one or other of the known forms of sulphur-reducing bacteria may prove serviceable.

In conclusion, recognition of the services rendered by Mr. William Camps of this Station throughout the whole of these investigations must be given. Reference was made in the last progress report to the important part he has taken in this work. He has contributed similarly to the attainment of the new results here recorded.

BIBLIOGRAPHY.

(1) Karl Arens. *Jahrbücher für wissentschaftliche Botanik.* (*Pringsheim*). LXX, 93-157.

(2) Von. Babo and Mach. *Handbuch des Weinbanes und der Kellerwirthschaft.* Bd. II. 1910, 127-8.

(3) Barker, Gimingham and Wiltshire. *Long Ashton Research Station Annual Report,* 1919, 57-75.

(4) Barker. *Long Ashton Research Station Annual Report,* 1927, 72-80.

(5) Goodwin and Martin. *Ann. App. Biol.* XV, 623.

(6) Goodwin, Martin and Salmon. *Journ. Agric. Sci.* XX, 18.

(7) Marsh. *Journal of Pomology and Horticultural Science,* VII, 237, 1929.

(8) Martin. *Journ. Agric. Sci.* XX, 32.

(9) Pollaci. *La Gazetta chimica Italiana,* V, 451-460. 1875.

(10) Salmon. *Journ. Min. Agric.* XXVIII, 150.

PLATE I.

Description.

A. A photograph of a lead acetate paper print obtained by clamping the paper to the lower surface of a strawberry leaf dusted with flowers of sulphur. The dark area corresponding to the actual form of the leaf is caused by the formation of lead sulphide where hydrogen sulphide has been evolved as the result of the interaction on the stomatal surface of the leaf.

Note the absence of sulphide production along the course of the leaf veins.

B. A corresponding photograph of a lead acetate paper clamped to the sulphured upper surface of the same leaf at the same time.

Note the complete absence of sulphide formation, except in the irregular dark patches. These represent the places where parts of the lower surface of the leaf were bent over accidentally during clamping and thus brought into contact with the paper.

OBSERVATIONS ON THE DISEASES OF MARKET-GARDEN CROPS IN THE VALE OF EVESHAM.

By Lawrence Ogilvie.

With a view of gaining some knowledge of the plant diseases in the important market-gardening area in the Vale of Evesham, a survey of this region was commenced by the writer in 1928. It was found that several obscure diseases were causing losses of considerable economic importance. Studies on the subject were therefore continued in 1929 and are to be further developed in 1930. The following notes will give some idea of the present situation.

Asparagus Diseases.

Violet Root Rot of Asparagus.—This disease, caused by the fungus *Helicobasidium purpureum* (*Rhizoctonia Crocorum*), was apparently much more common formerly than it is now. In 1916 and 1917 it had become so prevalent that trials of various chemicals were carried out with a view to its control (1). At the present time there are in the area only a very few widely scattered centres of infection. The affected circular areas usually attain a diameter of some 10-15 feet before they are apparent to the grower by the dying off of the "bower." On digging up the plants the grower finds that the roots are covered with the characteristic reddish violet mycelium of the fungus which here and there becomes aggregated into the so-called "corps miliaires" or infection cushions. The method of control successfully adopted is to dig out and burn all the affected roots and plant the area with a non-susceptible crop, such as Brussels sprouts.

In view of previous reports of the susceptibility of carrots to this fungus in the Evesham area, attempts have been made to infect carrots with a pure culture, but without success. Neither has the fungus been found on any other crop or wild plant in the Evesham district.

Asparagus "Sickness."—The so-called "asparagus sickness" is characterised by a slow deterioration of the plants in certain fields, especially in areas, adjacent to villages, which have long been under cultivation. Whereas formerly the asparagus plants remained in a productive condition for some ten to fifteen years, at the present time they cease to be productive, in the areas in question, after about seven years, or even less.

The diseased plants throw up spindly shoots of no market value. They are scattered irregularly throughout the affected beds and it is evident that there is a progressive deterioration from year to year, the percentage of spindly shoots increasing till the beds are worthless.

In a normal asparagus plant, growth proceeds by the production of new aerial shoots year by year at the end of the rootstock. From these, new roots are produced, so that the rootstock appears as a longitudinal structure, at one end of which are the remains of the original shoots and at the other end the current year's shoots.

In the case of normal plants the roots continue to function as storage organs for some three years, the older roots tending to become hollow. The dying off of these roots is associated with the appearance in the cortex of small, corky, reddish-brown areas which are well defined and which extend inwards from the surface, commencing at the point of origin of a dead fibrous root. Fungus mycelium is absent from these areas in their early stages, but when an inch or so of the root is affected they become invaded by fungi and bacteria. A large number of species of *Fusaria* have been isolated from such areas. The commonest fungus in the later stages of root decay is one forming purple sclerotial cushions strikingly similar to those of *Helicobasidium purpureum*, and closely related to *Fusarium sclerotioides*. None of these fungi have been found to be markedly pathogenic when placed in contact with pieces of roots in petri-dishes or with the roots of asparagus plants grown from surface sterilised seeds in sterilised soil in pots. Neither have bacteria isolated from the later stages of decay been found to be capable of destroying the roots.

The only striking difference between the roots of plants bearing spindly shoots and normal plants is that, in the former, the dead areas are somewhat more numerous so that the storage roots last only two years or so. Fewer fresh roots are also produced.

As the theory of the pathogenic origin of the sickness did not seem to hold, an attempt was made to correlate it with some other factor. It is well known that much of the soil in the Evesham area is relatively deficient in potash and that in many cases no manure at all is applied to the asparagus from season to season. There are indications that applications of potash in the form of Kainit will yield strikingly vigorous plants in areas where the crop will otherwise fail rapidly, while in the asparagus manurial trial laid down in March 1926, by the Department, in co-operation with the Worcester County Agricultural Organiser, there is already some indication of the beneficial effect of applications of sulphate of potash, although the amount applied was only 2 cwts. per acre per annum.

Asparagus Rust (*Puccinia Asparagi*) was apparently prevalent in the area for one or more seasons some twenty years ago, but is not now found there.

Diseases of Dwarf Beans.

Dry Root Rot.—Complaints have recently been received from Evesham growers of the failure of dwarf bean plants towards the time of podding, the pods being few in number and of poor size and the crop being very adversely affected thereby.

The disease was found to be very prevalent all over the Evesham area, in the neighbourhood of Evesham itself and at Badsey, Bretforton, Offenham and Child's Wickham.

The effects of the disease are at first not very evident on the aerial parts of the plant, but if the plant is pulled up, characteristic sunken reddish or reddish-brown lesions will be observed at the base of the stem. In severe cases the base of the stem has a dry shrivelled appearance, while root growth is severely restricted, the roots being also reddish in colour. If the disease is confined to the extreme base of the stem, fresh roots may be put out above the lesions.

The effect of the disease on the aerial parts of the plant is usually not evident till the first pods have grown to their full size. Subsequently the lower leaves begin to turn yellow and wither at the edges and the later-produced pods shrivel up before they become quite full. Counts of pods on healthy and diseased plants show that the disease may reduce the yield in the field to less than one half.

Longitudinal sections of the affected areas of the stem reveal the presence of an intracellular mycelium most frequent in those parts which are stained most deeply red. The red colour and the mycelium are almost entirely confined to the cortex, but in the case of the topmost roots hyphae occasionally penetrate into the vascular system, in which they induce the production of gum.

If affected stems are kept for a few days in a moist chamber, a blue fungus growth with abundant conidia will develop on the surface of the lesions.

A large number of isolations on malt extract agar were made from pieces of diseased tissue, previously surface-sterilised. In the majority of cases a *Fusarium* was produced which gave rise in culture to abundant pseudopionnotes which were predominantly blue in colour.

From an eight-weeks old culture on potato dextrose agar the size of conidia was as follows :—

2-septate, rare.
3-septate, 70%, 39.4 x 5.2μ (average of 50), (28.8-45 x 4-7.2μ).
4-septate, 30%, 46.1. x 5.4μ (average of 50), (39.6-52.5 x 4.1-5.8μ).

The colour of the pseudopionnotes was pale olive buff to cinnabar green.(*)

From an eight-weeks old culture on oat agar the size of the conidia was as follows :—

2-septate, rare.
3-septate, 43%, 39.8 x 5.3μ (average of 50), (23.4-54.8 x 5-5.8μ).
4-septate, 57%, 48.4 x 5.4μ (average of 50), (39.6-61.2 x 5-4-5.8μ).

The colour of the pseudopionnotes was as on potato dextrose agar.

From a six-weeks old culture on a steamed potato plug the size of the conidia was as follows :—

2-septate, rare.
3-septate, 28%, 41.7 x 5μ (average of 50), (32.4-50.4 x 4.3-7.2μ).
4-septate, 58%, 49.7 x 5μ (average of 50), 39.6-61.2 x 4.3-7.2μ).
5-septate, 14%, 51.5 x 6.5μ.
6-septate, rare.

The colour of the pseudopionnotes was dusky green-blue.

The mycelium is in each case predominantly white.

Steamed rice is coloured purple drab.

From a consideration of its cultural characters, the morphology of the fungus was considered to be identical with *Fusarium martii* var. *Phaseoli* as described by Walter H. Burkholder, (2) and this identification was kindly confirmed by Dr. Burkholder, to whom a culture was sent. In addition to the United States, the fungus has been recorded from Australia and from Spain, but apparently has not been previously recorded in this country. For a detailed account of the disease as it occurs in America, the reader is referred to Dr. Burkholder's paper.

Bean plants grown in soil artificially infected with the fungus became infected in every case. Plants of the variety "Early Prolific," grown in the greenhouse from surface-sterilised seeds, sown on August 15th, in sterilised soil to which had been added a culture of the fungus, showed abundant and typical infection by October 15th. Check plants remained healthy.

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* The colours are after Ridgeway's "Colour standards and colour nomenclature."

All the varieties of dwarf beans commonly grown in the Evesham area, " Bountiful," " Market King," " Early Prolific," " Canadian Wonder " and " Black Prince " become affected with the fungus. Runner beans (*Phaseolus multiflorus*) are also susceptible, but the infection does not check the growth of the plant to any marked extent. Trials are to be carried out next season with a view to ascertaining whether a resistant variety can be found.

In a small area at Bretforton which had lain fallow for three years the disease appeared subsequently to be as prevalent as on the rest of the area, and experience in the United States also suggests that little control can be expected from rotation of crops.

Diseases of Peas.

Foot Rot.—A foot rot of peas characterised by blackening and necrosis of the cortical tissues of the base of the stem and the topmost roots is of considerable importance in the area, bringing about an early dying off of the plants. Preliminary observations suggest that a *Fusarium* is responsible. Trials for varietal susceptibility have been arranged.

Bacterial Disease.—A disease, of less importance than the above, is prevalent in wet seasons. Water-soaked lesions, which subsequently become brown or black, occur on the leaves and stems and on the pods. On the pods these spots are especially striking. At first water-soaked, depressed, and somewhat circular, they may spread and involve the whole pod if conditions are favourable. This disease has already been referred to, in last year's report, as probably being identical with that caused by *Pseudomonas Pisi*, Sackett, occuring in the United States.(3)

Downy Mildew (*Peronospora Viciae*) is common in the area, but is of little economic importance.

Diseases of Onions.

White Rot.—The most important disease of onions in the area is white rot, caused by *Sclerotium cepivorum*, which interferes considerably with the growing of bunching onions. Through the co-operation of Mr. E. Holmes Smith, of Manchester University, trials of " White Welsh " (a resistant variety) as a substitute for the bunching onion " White Lisbon " are being made on infected ground in the Badsey area.

Downy Mildew (*Peronospora Schleideni*) occurs sporadically during wet seasons, but is of little economic importance.

Miscellaneous Diseases.

Foot Rot of Asters (caused by species of *Fusarium*).—Is an especially troublesome disease in areas where asters are grown year after year.

REFERENCES.

1. Barker, B. T. P. and Gimingham, C. T. "Experiments on the treatment of Rhizoctonia disease of Asparagus." *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton, Bristol*, 1916, p. 39; and "Further experiments on the Rhizoctonia disease of Asparagus." *Ibid.*, 1917, p. 28.

2. Burkholder, W. H. "The Dry Root Rot of the Bean." *Cornell Univ. Agr. Expt. Stn., Memoir* 26, June, 1919.

3. Sackett, W. G. "A bacterial stem Blight of Field and Garden Peas." *Colorado Agr. Coll. Expt. Stn., Bull.* 218, April, 1916.

SPRAYING TRIALS AGAINST APPLE SCAB. II. SEASON 1929.

BY J. G. MAYNARD AND R. W. MARSH.

The trials of 1929 were continued on the same lines as those of 1928, *i.e.* spraying was carried out on a commercial scale, using large blocks of trees and taking full records of all costs and of scab control and spray damage (see Long Ashton Ann. Rept. 1928. pp. 112-123). It is believed that only by such methods can recommendations of direct value to commercial fruit growers in the West of England be formulated. To be practicable, a spraying programme must fulfil the following requirements :—

(1) It must give scab control of a high order.
(2) The cost of application must be at an economic level.
(3) The speed of application must be as great as possible.
(4) Spray damage must be avoided.

It was found in 1928 that the use of a power sprayer and spray guns greatly increased speed of application and so reduced the costs. This system also gave a very thorough " cover " of spray, and could be employed on days of relatively strong wind. These advantages made possible the application of two thorough sprayings before blossom time, and this was followed by one post-blossom application. The crop from the trees thus treated showed almost complete freedom from scab, the standard of control being much higher than had hitherto been recorded by investigators working with low pressure and the " fine, misty " type of spray.

THE PLOTS.

As in 1928 (see Long Ashton Report), plots 7*b*, 7*c*, and 8*a* were employed, together with plot 11, a description of which is given hereunder.

Plot 11 (2 *acres*).

This comprises 340 young bush apples planted as two-year-olds in the autumn of 1923. The trees stand on the square at 15ft. intervals in 17 rows each of 20 trees. In every case each row, running from N. to S., is of a single variety, the sequence of the rows from W. to E. being—Bramley, Worcester, Newton, Grenadier, Blenheim, Charles Ross, King of the Pippins, Beauty of Bath, Ontario, Wealthy, Lane, Bismarck, Rival, Cox, Wellington, Jubilee, Allington.

In autumn 1928, two wide strips of the plot were grassed down, the grass strips crossing from E. to W. (*i.e.* at right angles to the single-variety rows). The first grass strip includes all the trees from the third to the eighth in each variety row, the second, those from the twelfth to the seventeenth. The remainder of the plot is under clean cultivation : there are no undercrops. A metalled road runs along the north side of the plantation.

The size of the trees in this plot varies between a maximum of 12ft. height and 8ft. spread and a minimum of 4ft. height and $\frac{3}{4}$ft. spread. The over-all average is 8ft. height and $4\frac{1}{4}$ft. spread, indicating that in this young plantation there is still a considerable space (approx. $10\frac{3}{4}$ft.) between the heads of adjacent trees.

Spraying Programme.

As was pointed out in the 1928 report, the two pre-blossom sprays given in that year approximated very nearly to a double spray given at the " green flower " stage. In the 1929 programme, taking into consideration the diminution of the sources of infection as a result of the previous year's spraying, a single pre-blossom spray was given. This spray was, however, applied at the " green flower " stage and not at the " pink " stage as usually recommended for a first application. Certain of the plots were not afterwards sprayed* and the colloidal sulphur spray was used at a strength which brought the cost of the spray fluid to approximately the same level as that of 1 in 20 lime sulphur. The full programmes for the two years are given opposite.

The 50 trees of Grieve on plot 7*c* were treated in five blocks of ten as follows :—

(1) Pre-blossom Bordeaux and post-blossom Bordeaux

(2) Pre-blossom colloidal sulphur and post-blossom colloidal sulphur.

(3) Pre-blossom lime sulphur and post-blossom lime-sulphur.

(4) Pre-blossom Bordeaux and post-blossom colloidal sulphur.

(5) No spray.

In the row of 13 Cox's Orange Pippin, all the trees were given a pre-blossom application of Bordeaux, and, in the post-blossom stage, alternate trees were given Bordeaux and colloidal sulphur.

The control trees available in 1929 comprised the row of Lanes similarly employed in 1928 and the block of 10 James Grieve

* It was intended to use dusts in the post-blossom stage, but this detail of the programme had to be postponed.

Plot.	Variety.	SPRAY PROGRAMME 1928. Pre-blossom.	SPRAY PROGRAMME 1928. Post-blossom.	SPRAY PROGRAMME 1929. Pre-blossom.	SPRAY PROGRAMME 1929. Post-blossom.
7*b*.	Lane	Bordeaux 4-9-50 (twice)	Bordeaux 2-4-50	Lime Sulphur 1-20	Bordeaux 2-4-50
	Worcester	Do.	Do.	Do.	Coll. Sulphur 2-100
	Bramley	Do.	Do.	—	—
7*c*.	Lane	Bordeaux 4-9-50 (twice)	Coll. Sulphur 10-100	Bordeaux 4-9-50	Bordeaux 2-5-50
	Worcester	Do.	Do.	Do.	—
	Newton	Do.	Do.	Do.	—
	Allington	Do.	Do.	Do.	—
	Edward	Do.	Do.	Do.	—
	Grieve	Do.	Do.	(see under)	
	Cox	Do.	Part Bordeaux 2-5-50 „ Coll. Sulphur 10-100	(„ „)	
8*a*.	Allington	Bordeaux 4-9-50 (twice)	Bordeaux 2-4-50	Lime Sulphur 1-60	Lime Sulphur 1-60
	Edward	Do.	Do.	Do.	Do.
11.	Cox	—	—	Bordeaux 4-9-50	—
	Lane	—	—	Do.	—
	Allington	—	—	Do.	—
	Worcester, etc. ..	—	—	Do.	—

mentioned above. On the row of Lanes, scabbed wood could easily be found in the early spring of 1929, but on plots 7*b*, 7*c* and 8*a* it was extremely rare.

Pre-Blossom Spray.

The pre-blossom spray was applied on April 8th to the Worcesters and Lanes on plot 7*c* and on the 9th and 10th to the remaining varieties on that plot. Plot 11 was also sprayed on the 9th. The Allingtons and Edwards on plot 8*a* were sprayed on April 23rd-24th and the Grieves on April 27th. The Worcesters and Lanes on plot 7*b* were sprayed on May 2nd.

The methods of application were generally as described in the 1928 report, but no spraying was done from the machine in motion. In plots 7*b*, 7*c* and 8*a* mains were laid down, and for the infrequent moving of the machine on the headlands, either man-power or the horse was utilised. For the small trees on plot 11, the power sprayer was not used, these trees being sprayed with knapsacks. Full details of the spraying on plots 7*b* and 8*a* are to be found in the final tables, and other details are given in the spraying programmes.

Weather.

The weather on April 8-9 was sunny; on the 8th there was a S.W. wind at 10 m.p.h. and on the 9th a N.N.W. wind at 15 m.p.h. April 10th was cloudy with 0.02in rain; the wind was northerly and moderately strong (15-20 m.p.h.). The next fortnight continued fine except for a fall of 0.13in. of rain on the 13th. Winds were light to moderate, chiefly from the N. and E. Temperatures were abnormally high (72° max.) on the 18th and 19th. The 23rd was overcast with a N.N.E. wind at 12 m.p.h. The following day was sunny with the wind S.W. and blowing from 15-20 m.p.h. The month as a whole was sunnier, and even drier than in 1928, the total rainfall being 0.9in. compared with 1.39in. in the previous year.

May 2nd was fine with a N.N.E. wind (15 m.p.h.); on the 4th and 5th there was heavy rain, with lighter falls continuing up to the 13th. The succeeding fortnight was characterised by abundant sunshine and high temperatures.

Spray Damage.

As in 1928, it was found that, apart from transitory leaf scorching, there was no spray damage resulting from the pre-blossom application. Records of this temporary damage are not given in the present paper.

Post-Blossom Spray.

On the Allingtons and Edwards of plot 8*a* the post-blossom spray was applied on May 28th. The Worcesters and Lanes of plot 7*b* and the Lanes on plot 7*c* were sprayed on the 31st. The Grieves and Cox's on the latter plot were treated on June 1st. These treatments were all carried out using movable steel mains as previously described.

Weather.

May 28th was fine with a strong N. wind (20 m.ph.); this had moderated to 8 m.p.h. by the 31st. While May of 1928 was an abnormally cold month with a mean maximum temperature of 52.3°, May 1929 gave a corresponding mean of 62.6°.

The first fortnight of June was rainy, 1in. falling in the first six days. On June 12th the rainfall was 0.58in., on the 13th, 0.1in., 0.36in. on the 14th and 0.14in. on the 15th. The humidity on the 13th was 92 and the maximum temperature 65°. The appearance of scab on unsprayed trees towards the end of June suggests that this period, June 12th-15th, was one in which a considerable extension of scab infection took place.

Spray Damage.

The spray damage up to August 24th resulting from the post-blossom application is listed below :—

Plot.	*Variety.*	*Spray Fluid Employed.*	*Damage.*
7*b*.	Lane ..	Bordeaux 2-5-50	Fruit russetted.
	Worcester ..	Colloidal Sulphur 2-100 ..	None.
7*c*.	Lane ..	Bordeaux 2-5-50	Fruit russetted.
	Grieve ..	Do.	Fruit badly russetted.
	„ ..	Colloidal Sulphur 2-100 ..	None.
	„ ..	Lime Sulphur 1-60	None.
	Cox ..	Bordeaux 2-5-50	Leaves scorched and fruit russetted.
	„ ..	Colloidal Sulphur 2-100 ..	Fruit slightly russetted.
8*a*	Allington ..	Lime Sulphur 1-60	None.
	Edward ..	Do.	None.

Yield of Clean and of Scabbed Fruit.

On the unsprayed row of Lanes and on the control block of Grieves in plot 7*c*, scab was plentiful on the leaves during August, and was beginning to be obvious on the fruit. At the same time, the next two blocks of this latter variety showed slight scab on the foliage. By the end of August, the trees of Cox on this plot showed a little scab on the leaves. Scab was also apparent on the

leaves of the Allingtons and Newtons in plot 7*c* (which had received only one spraying). In the remainder of the sprayed plots no scab was seen up to the time of picking.

On picking, counts were made as in 1928, and all fruits showing any scab whatsoever were counted as scabbed. The results are on the following page.

General Review.

The efficacy of the scab control in 1929 was again noteworthy. From the trees twice sprayed, approximately 20 tons of fruit were harvested and in this only 837 fruits showed any scab whatsoever It will be noted that 733 of these scabbed fruits were confined to the two blocks (40 trees) of Grieves which adjoined the unsprayed block of that variety.

The authors again ascribe the success in obtaining scab control to the thorough spraying in the "green flower" stage. Recent American work has once more stressed the importance of the early infection of the leaves resulting from the scab pustules on the twigs, and has pointed out the part which these early centres of leaf infection play in the subsequent infection of the fruit. It is believed that the early heavy spraying effectively stops this first establishment of scab on the leaves and so checks from the outset the multiplication of sources of infection. Even on the plots at Long Ashton sprayed once in 1929, the amount of clean fruit was in no case less than 83 per cent., a figure which might be compared with those obtained where late and light scab sprayings are practised.

It may be asked what part the previous year's spraying treatment played in bringing about these results and, in the absence of large control blocks of trees it is not possible to give an adequate answer. However, the 1929 control block of Grieves, on which scab was reduced to 5.96 per cent. in 1928 showed 43.75 per cent. scab when left unsprayed the following year.

Concerning spray damage, the Grieves in 1929 showed serious russetting and cracking following a post-blossom weak Bordeaux application, while remaining uninjured by colloidal sulphur (2-100) or lime-sulphur (1-60). On Cox, also, serious damage followed a post-blossom 2-5-50 Bordeaux application, as was anticipated. On the same variety, russetting was also seen following a post-blossom colloidal sulphur spray (2-100) but in the absence of controls it cannot be definitely stated that this damage was the effect of the sulphur spray.

Yield of Clean and of Scabbed Fruit.

A. SPRAYED TWICE.

Plot.	*Variety.*	*Spray Treatment.*	*Total Fruits.*	*Scabbed Fruits.*	*Per cent. Scabbed.*	*Notes.*
7*b*.	Worcester	Lime sulphur and colloidal sulphur ..	17,348	12	0.07	
	Lane	Lime sulphur and Bordeaux	7,655	0	0	
7*c*.	„	Bordeaux and Bordeaux	2,647	0	0	
8*a*.	Allington	Lime sulphur and lime sulphur	184,062	34	0.02	
	Edward	Do. Do.	7,370	0	0	
7*c*.	Cox	Bordeaux and Bordeaux	395	23	5.82	Adjoining control block of Grieves.
	„	Bordeaux and colloidal sulphur ..	250	28	11.20	
	Grieve	Bordeaux and Bordeaux	1,483	3	0.21	
	„	Colloidal sulphur and colloidal sulphur	1,465	4	0.28	
	„	Lime sulphur and lime sulphur ..	2,048	429	20.97	Adjoining control block (unsprayed).
	„	Bordeaux and colloidal sulphur	1,540	304	19.48	
		Total for all trees twice sprayed	226,263	837	0.37	

B. SPRAYED ONCE.

7*c*.	Worcester	Bordeaux	1,626	7	0.43	
	Allington	„	4,222	343	8.14	
	Newton	„	3,764	613	16.28	Examined 3 months after picking.
11.	Worcester	„	1,358	9	0.65	8 from cultivated, 1 „ grass.
	Lane	„	216	1	0.48	1 from cultivated strip.
	Allington	„	1,220	7	0.58	3 from cultivated, 4 „ grass.
	Cox	„	390	35	8.97	29 from cultivated, 6 „ grass.

C. CONTROLS—Not Sprayed.

9.	Lane	—	5,317	2,768	52.00	
7*c*.	Grieve	—	2,144	938	43.75	

On Lanes, the post-blossom Bordeaux caused moderate russetting (without cracking) irrespective of whether Bordeaux or lime-sulphur had been used in the pre-blossom stage. As this variety had been shown in the 1928 trials to be also sensitive to sulphur injury in the post-blossom stage, a special problem is raised which will be dealt with in subsequent trials.

Certain varieties have now been shown over the two years investigations to be tolerant of either of two or more different sprays in the post-blossom stage. Allingtons and Edwards have shown no damage following post-blossom applications of 2-5-50 Bordeaux, 1-60 lime-sulphur or 10-100 colloidal sulphur. On Worcesters, Bordeaux 2-5-50* and colloidal sulphur are safe post-blossom applications and Grieves after blossoming will take lime-sulphur 1-60 or colloidal sulphur 10-100 without injury.

In considering costs of spraying, one point requiring further explanation is the amount of spray fluid used per tree. The figures given in this and the previous paper have been criticised as being much greater than those accepted by other investigators of this problem. In this connection, the insistence at Long Ashton on a thorough drenching spray must again be stressed. It should also be pointed out that days without wind occur very rarely at this Station (in 1928 there were only 5 days recorded as calm in the whole year). As it would consequently be impossible to carry out any spraying programme if one waited for still conditions, most of the spraying at Long Ashton is carried out in winds of from 8 to 20 miles per hour, and not infrequently on gusty days when the wind velocity rises to 30 m.p.h. It may be considered that this factor vitiates the value of the figures of spray fluid consumption given, but it seems more probable that the commercial grower wishing to spray during the spring in the West of England will be equally unlikely to meet with spells of windless weather, and must be prepared to carry out his spraying programme under more or less windy conditions.

The costs of spraying have been given only for plots 7*b* and 8*a* since the spray applications on these plots were comparable with those that would be made commercially. The multiplicity of treatments on plot 7*c* renders the figures of little comparative value, and the trees of plot 11 are smaller than those generally sprayed in commercial plantations. The figures of hours worked given in the table of costs show a marked reduction from those put forward in

*Examples are known of damage to Worcesters following a post-blossom Bordeaux spray at full strength (4-10-50).

1928. This is attributed partly to the better weather conditions during the spring and, still more, to increased efficiency following upon repeated use of the spraying outfit on the same blocks of trees.

In the figures of total man-hours, the time accounted for by water carting and delays has this year been separated and the costs due to these causes have been deducted from the total costs. This arrangement has been agreed upon after consultation with other investigators of spraying costs because it is considered that the time consumed in this way is due to local and accidental causes, and is not a factor directly dependent on the system of spraying.

Summary.

1. Detailed observations on scab control, spray damage and costs of spraying have been continued on plots of commonly grown apple varieties at Long Ashton in 1929.

2. On practically all of the plots sprayed the treatments were carried out on a commercial scale, using a power sprayer and spray guns. Thoroughness of application was insisted upon.

3. Certain of the treated plots received one pre-blossom and one post-blossom spray ; others a pre-blossom spray only. The pre-blossom applications were made at or about the "green flower" stage.

4. The total yield of fruit on the varieties twice sprayed was approximately 20 tons. Of this 99.63 per cent. was entirely free from scab.

5. Data are presented relating to Bordeaux injury on James Grieve, Cox's Orange Pippin and Lane's Prince Albert.

6. Costs of certain of the spray applications are set forth in detail. The labour costs show a considerable reduction on the comparable figures for 1928, partly due, it is believed, to increased efficiency in the use of the spraying outfit.

COST OF PRE-BLOSSOM

Plot	No. of Trees	Dates	Spray Fluid	Materials							Total Cost of Materials	Cost per Tree	Gall. per Tree
				Substance	Amt.	Cost	Sub-stance	Amt.	Cost	Water			
										galls.			
7*b*. (part of)	192	2.5.29	Lime Sulphur 1-20	Lime Sulphur concentrate	10 gall.	16/8	—	—	—	200	16/8	1d.	1.0
*8*a*	338	23.4.29 24.4.29	Lime Sulphur 1.60	Do.	13 gall.	22/8	—	—	—	760	£1/1/8	¾d.	2.3

* Remarks.—Wind 15-20 m.ph. on April 24. One hour delay due to blow-out in main. Two hours thawing out and relaying pipes.

COST OF POST-BLOSSOM

Plot	No. of Trees	Dates	Spray Fluid	Materials							Total Cost of Materials	Cost per Tree	Gall. per Tree
				Substance	Amt.	Cost	Sub-stance	Amt.	Cost	Water			
7*b*. (part of)	96	31.5.29	Colloidal Sulphur 2-100	Colloidal Sulphur concentrate	3 gall.	4/-	Soft Soap	lb. 6	1/2d.	150	5/2	¾d.	1.5
7*b*. (part of)	96	31.5.29	Bordeaux 2-5-50	Copper Sulphate	3 lb.	1/1½	Lime	7½	4½d.	150	1/6	¼d.	1.5
*8*a*.	338	28.5.29	Lime Sulphur 1-60	Lime Sulphur concentrate	20 gall.	33/4	—	—	—	1200	£1/13/4	1.2d.	3.5

* Remarks.—Wind 20 m.ph. Replacement of blown out mains, 20 minutes.

SUMMARY OF

7*b*.	Pre	£1	2	6		
	Post	£0	16	7		
		£1	19	1	=	2.5d. per tree.
						£1 14 0 per acre.

SPRAY APPLICATION.

Labour							Transport					Total Cost of Labour Materials and Transport	Cost of Water-carting and Waste Time (Dedct)	Nett Cost	Cost per Tree
Man-Nozzle Hours	Attendant Hours	Hours Laying-out	Hours Waste Time	Horseman Hours.	Total Man-Hours	Total Labour Cost at 10d. Hr.	Tractor		Horse		Total Transport Costs				
							Hrs.	Cost	Hrs.	Cost					
4	2	1	—	1½	8½	7/1	—	—	1½	1/6	1/6	£1/5/3	2/9	£1/2/6	1.5d.
9	4½	1	5	7½	27	£1/2/6	—	—	7½	7/6	7/6	£2/11/8	17/11	£1/13/9	1.2d.

SPRAY APPLICATION.

Labour							Transport					Total Cost of Labour Materials and Transport	Cost of Water-carting and Waste Time (Dedct)	Nett Cost	Cost per Tree
Man-Nozzle Hours	Attendant Hours	Hours Laying-out	Hours Waste Time	Horseman Hours	Total Man-Hours	Total Labour Cost at 10d. Hr.	Tractor		Horse		Total Transport Costs				
							Hrs.	Cost	Hrs.	Cost					
5¼	3	3	—	3½	14½	12/1	¼	6d.	3¼	3/3	3/9	£1/2/6	5/11	16/7	1d.
12¾	6	3½	1	6½	29½	24/7	¼	6d.	6½	6/3	6/6	£3/4/5	12/3	£2/12/2	1.9d.

NETT COSTS.

8*a*. Pre £1 13 9
Post £2 12 2

£4 5 11 = 3.1d. per tree.
£2 3 0 per acre.

SUPPLEMENTARY NOTE ON THE CONTROL OF BLACK CURRANT LEAF SPOT.

By R. W. Marsh and J. G. Maynard.

In the previous Report (Long Ashton Ann. Rept., 1928, pp. 109-111) a method for the control of black currant leaf spot by spraying was described. About 3,000 bushes of the variety Baldwin in the Long Ashton plantations were sprayed with Bordeaux mixture on July 20th, 1928, *i.e.* directly after cropping, while a block of 340 bushes on the same plot was left unsprayed as a control. These control bushes became heavily attacked by the leaf spot fungus in the following month and suffered complete defoliation by early September. The sprayed bushes, on the other hand, retained their foliage in a healthy condition until the normal time of leaf fall (October-November). On November 8th, 1928, it was found that the buds from the sprayed plots were on the average 15.3 per cent. heavier than those from the unsprayed, and it was suggested that a difference would also be shown in the crop weights during the subsequent season.

The figures for these crop weights are now available. The block left unsprayed in 1928 comprised ten rows of bushes and the weight from this block is given below together with the weights from three comparable blocks of sprayed bushes adjoining. On all the bushes, the crop was light due to unfavourable weather at the time of flowering. The weights were recorded on July 23rd-26th, 1929, and are as follows :—

	lbs.	ozs.
Total weight from rows 3-12 (sprayed 1928)	338	10
„ „ „ 13-22 („ „)	322	10
„ „ „ 23-32 („ „)	330	7
„ „ „ 33-42 (not sprayed)	261	7

The average weight of fruit from an unsprayed row is thus seen to be 26 lb. 2 oz. : that from a sprayed row is 33 lb. 1 oz.—an increase of 26 per cent. as a result of the spraying in 1928.

After the picking of the 1929 crop, the main block of Baldwins was not sprayed until August 10th-12th, when three-quarters of the

plot was sprayed with 2-4-50 Bordeaux mixture. At the same time a small block was dusted with a copper-lime preparation. The remainder of the plot (about 800 bushes) was left unsprayed. At the time that these applications were made the disease had made very considerable progress and some defoliation had set in. Nevertheless the Bordeaux spraying arrested the attack : the dusting, on the other hand, had only a slightly favourable effect.

On another plot, a spraying with 2-4-50 Bordeaux mixture on August 2nd was completely effective in preventing the premature defoliation due to the attacks of the leaf-spot fungus.

To sum up, the results obtained in 1929 have demonstrated the loss of crop consequent upon attacks of black currant leaf spot. The value of a Bordeaux spray in the control of this disease has been confirmed and the importance of applying the spray as soon as possible after cropping has been emphasised. If, however, it is not possible to apply a spray directly after cropping, it is shown that an attack of black currant leaf spot which has reached in August the stage of slight defoliation may yet be arrested by application of Bordeaux mixture.

THE ECONOMICS OF SPRAYING FRUIT TREES.

II. THE COST OF SUMMER AND WINTER WASHING, 1929 and 1930.

By J. G. Maynard.

Introduction.

In the Annual Report for 1928 a detailed account of winter spraying 1928-29 with costs was given. At the same time the methods of spraying in use on the farm were described, and full details of the equipment used were given. No material changes in either have taken place since the publication of that report. Spraying with various types of machines varying from knapsacks to power spraying equipment indicated that on the farm it was more economical in almost all cases to use power equipment than either knapsacks or a headland hand pump type of machine. This has led, in the season under review, to the power spraying equipment being used almost exclusively and spray guns have been employed invariably in conjunction with it. For the plots mentioned in this report a system of metal main lay-out such as was described in the last report has been adopted where it was necessary to use more than the ordinary lengths of rubber hose pipes.

The costs of spraying given in the last report related only to winter washing. The materials used represented several variants of tar distillate wash under trial and the actual cost per gallon of concentrate was taken as that of the cost of the commercial brands available on the market. It may be mentioned in passing that the results obtained in all cases from the winter washing were entirely satisfactory, a complete control of all the pests regarded originally as controlled by winter washing being obtained. Capsid bug has never been prevalent on the Long Ashton farm, but the traces of this found in the summer of 1928 were probably destroyed, since in the summer of 1929 no capsid was observed.

In the same Annual Report an article by Maynard and Marsh dealt in detail with spraying operations against apple scab, including spraying costs on certain plots and particulars of the control

measures adopted. The results in this case gave from 94% to 100% clean fruit. A further article on the same subject by these authors in the present Annual Report shows that equally good or even better results were obtained in 1929. This point is stressed because it is obviously of the first importance in considering the cost of spraying to know the standard of pest control obtained.

The 1929-30 Data.

With the exception of one experimental wash on trial on Plot 7*b* (Table II) the materials used in the work under review have been ordinary commercial products such as Lime Sulphur, excess lime Bordeaux, the Long Ashton two-solution winter wash and one of the well-known proprietary winter washes of the older type. The cost of these has been taken at the current market prices. No definite cost could be given to the materials in the experimental wash, but the figures for time of application, etc., are given in Table II for purposes of interest.

Complete details of some of the scab spraying are given in the article by Marsh and Maynard mentioned above and appearing in this Report.

The main feature of interest is the reduction of cost in the year under review as compared with the previous year.

Table I.

Table I gives particulars of weather conditions and details of the trees and bushes sprayed. It is worth noting that no trouble resulting from frost was experienced in this season and there were actually fewer frosty mornings than in the 1928-29 winter. Leaving out of consideration delays due to frost the time required to spray a comparable amount of trees was very much less than in 1928-29. Thus winter spraying plots 1, 2, 4*a*, 6, 7*b*, 7*c*, 8*a*, 10, 11, 11*a*, 14, 15, 20 and Hillside in the earlier year occupied 225¾ spraying hours and in the following only 119¾ spraying hours. In the latter, moreover, considerably more trees—30 year old apple standards chiefly—were sprayed on plot 1 and there was also the added growth of another season on all other plots. This reduction in the total time is far greater than can be accounted for simply on the score of better weather conditions. A considerable proportion of the saving of time has been effected by using the power equipment instead of knapsacks. An example of this occurs on plot 4*a* : spraying in December, 1928, with two knapsacks occupied 17¼ hours, while in January, 1930, with power and two guns the time was reduced to 4 hours.

In this connection it is interesting to note that Lime Sulphur spraying with two knapsacks in the spring of 1929 took 17 hours, or practically the same time as the winter spraying for 1928-29 applied with the same equipment. A Bordeaux spray applied for leaf spot on the same plot in the summer of 1929 after the season's growth was almost complete and with the bushes in full leaf took 16 spraying hours with power: for the same bushes (without foliage) with the same spraying equipment in the winter of 1929-30 only 4 hours were taken. A similar state of affairs occurred on plot 6, where in 1928 two knapsacks worked for 44 hours; in 1929 the power sprayer and three guns finished the work in 4 hours spraying time.

It would be hard to over-emphasise the importance of this speed of work. Not only does it bring about a direct cash saving, but it enables a great deal more spraying to be done in suitable weather for such work than when the spraying programme has to be carried out with slow working tools. This latter point is very hard to assess monetarily, but any practical producer will readily and rapidly appreciate its value.

The actual direct cash saving between the use of knapsacks and power spraying equipment on plots 4*a* and 6 can best be seen thus :—

					£	s	d.
1928-29—Two knapsacks.	Plot 4*a*.	17	man spraying hours.	74 galls.	1	14	1
1929-30—Power and 2 guns	„	4¼	„	180 „	1	9	9
1928-29—Two knapsacks.	Plot 6.	44	„	258 „	3	14	0
1929-30—Power and 3 guns	„	4¼	„	230 „	2	10	0

As a general rule knapsacks use much less spray fluid than larger implements working at much greater pressure, but even this has not been the case on plot 6. The fact that less fluid was used by the power sprayer in this case can only be accounted for by the fact that there was hardly any wind during the very short time taken to spray in 1930, whereas there was some very rough windy weather in 1929 during the five days of knapsack spraying.

The work carried out on plots that had been previously sprayed with the same power sprayer was accomplished more cheaply in the 1929-30 period than in the previous year owing to a general improvement in efficiency rather than to any one single outstanding feature. Four guns were used where only two had been used before, thereby reducing overhead charges, and pressure was maintained at a higher mark than in the previous year.

One cheap technical improvement has been made in the spraying plant, which promises to be of considerable advantage in saving time and temper. Considerable loss of time and annoyance has frequently been caused by rubber pipes blowing off metal unions when working at high pressure. The following procedure has been adopted with a view to lessening this trouble, and although it has not been in use long, the treatment seems very promising. When the spraying equipment is being overhauled, all the rubber pipes are removed from the unions : where necessary a short length of rubber is cut off to provide a new end. The metal is thoroughly cleaned and then a little glacial acetic acid is brushed round it. The rubber pipe is pushed on at once and clamped in the usual way. The union is then left to dry for some hours. The effect is apparently to dissolve the rubber slightly and to make a sort of rubber solution which sticks firmly to the metal and the hose, forming a very good joint. Care should be taken not to get the acid on hands or clothes.

Table I I.

In Table II a series of figures is given relating to the costs on a number of plots. For purposes of comparison with last year's figures the " gross cost per tree " column should be used, The " nett cost per tree " column gives the cost less water cartage and waste time, etc. ; as these factors vary from farm to farm it is thought that the figures will be more easily applicable when thus expressed.

The Economics of Power Sprayers.

In the previous article dealing with this subject, it was claimed that expenditure appreciably higher than that of the current season report was justified, and it does not seem necessary to consider this point further here. It does appear important, however, to consider the cost of power sprayers in view of the fact that they are likely to give very economical working costs.

Efficient power sprayers that will carry four guns can be bought to-day for about £100. The annual cost of such a machine may be considered to be about £20. This figure has been arrived at as follows :—

	£	s.	d.
Interest on capital 5% on £100	5	0	0
Depreciation spread over 10 years	10	0	0
One man's wage for a week at sundry times decarbonizing, etc., and carrying out small repairs, etc.	1	15	0
Replacements (based on experience with an old power machine on this farm) average per annum	2	0	0
	£18	15	0

If the figure of £20 per annum be taken as the probable approximate annual cost of maintaining such a machine, it becomes, firstly, a matter of estimating what overhead charge per acre on the farm can be reasonably incurred under this head and what is the likely cash value of the saving in time spent on spraying with power equipment in comparison with a less elaborate outfit and then, afterwards, of assessing the value of speed in application, to which it is impossible to attach a definite money figure.

The absolute maximum acreage which such a machine is likely to be able to deal with is about 40 acres of fully grown bush apples. The basis for arriving at this acreage is that of the particular spraying operation which has to be done in the shortest possible time, *i.e.* one of the scab sprayings. To get satisfactory results from an application against scab there is probably about a period of 50 hours spraying time. This period of 200 gun hours implies that one gun must spray an average of 40 bush trees per hour on trees planted at 200 per acre.

Naturally this figure or acreage would be very much greater for younger trees, but on the above basis an overhead cost of approximately ten shillings per acre on fully developed trees is not high. Where, as on plot 6 gooseberries referred to already, a saving of over £1 is made on less than one acre of soft fruit by using power as opposed to knapsack, it becomes increasingly evident that an overhead charge of £20 per annum will soon be met by actual cash saving.

Costs Reduction.

The actual reduction in costs for the period under review, as indicated above, must be attributed to a general all round increased efficiency rather than to any one special economy.

The use of 4 guns on the machine in place of 2 has reduced the overhead costs and by doubling the output has reduced the necessity for working under unfavourable conditions. Also a second water cart has been brought into use, thereby avoiding delays in outlying parts.

The number of gallons applied per nozzle hour in the first year's winter spraying was approximately 50 gallons : in the second year it has been approximately 70 gallons. This has been accomplished by working at a slightly greater average pressure, made possible by the use of better pipe unions, fixed as described above.

A very rough examination of the liquid winter wash discharged by one gun gives the following figures :—

		120 lbs.	180 lbs.	280 lbs.
Reading of pressure gauge on engine ..				
Gallons per minute.	Gun fully open, coarse driving spray	3	3½	5
	Gun almost closed, misty spray	1¼	2½	3

These figures indicate that, with an absolutely continuous discharge, in one hour, a fully open gun will throw about 210 gallons and a gun set for a misty spray about 150 gallons at an 180 lbs. pressure reading on the machine. The average hourly discharge per gun in the 1929-30 trials is about 70 gallons, as just mentioned. This indicates that the so-called " spraying hours " in the table represent a period of time during the greater portion of which the nozzles are closed for moving from tree to tree or for some other cause apart from definite stoppages.

The fact that about one half of the " spraying time " is used in moving from tree to tree must be considered in the light of age of tree. Thus, when trees practically meet, only about a quarter of the time may be lost in moving : where trees are wide apart three quarters may be spent in moving from tree to tree. It is proposed to examine during the coming season certain methods by which it is hoped to reduce this lost time.

Provided that trees are grown under fairly satisfactory conditions of environment, spraying seems by far the most important of the various cultural operations. The cost of efficient spraying is one of the chief items of expense in production. The reduction of this expense to the lowest possible limit consistent with efficiency has thus a proportionately great effect on the nature of the balance sheet of the fruit farm and merits accordingly the closest attention of both the grower and the pomological investigator.

TABLE I. Plot and Weather Data.

Plot No.	Dates of spraying.	Wind.	Rain.	Frost. ° below 32° F.	Particulars of Plots and Trees.
1	6.2.30	8-18 M.P.H.	.01″	Nil	232 standard apples in grass, mainly about 30 years old, planted at 30 x 30ft.
	20.2.30	1- 7 M.P.H.	Nil	Nil	Area 5 acres approx.
2	2.1.30	12-24 M.P.H. (gusty)	Some drizzle	Nil	128 ½-standard plums, av. 12ft. spread, 11ft. height approx. Planted 15ft. by 30ft. ½-alleys intercropped with sundry soft fruit. Area 2½ acres approx.
4*a*	16.4.29	13-18 M.P.H.	Fine	Nil	1,634 young black currants, unpruned, due for second crop 1930. 1 acre.
	2.8.29	7 M.P.H. (calm)			
	3.8.29	19-24 M.P.H.	Wet	Nil	
	2.1.30	19-24 M.P.H. (gusty)	Rain	Nil	
	3.1.30	Ditto		Nil	
6	15.1.30	3- 7 M.P.H.	Fair	Nil	About 1,100 9-year old gooseberries, thinned slightly, 2/3 acres approx.
	16.1.30	Ditto		Nil	
7*b*	2.5.29	8-12 M.P.H.	Fine	Nil	288 bush apples and 12 damsons—1¾ acres. 10-year trees planted 15 x 15ft.
	31.5.29	4- 7 M.P.H.	Fine	Nil	Apples average height about 11ft. spread about 7ft., unpruned when sprayed.
	10.6.29	1-12 M.P.H.	Fine	Nil	2.5.29 spraying (192 trees). 31.5.29 spraying (192 trees).
	16.1.30	4- 7 M.P.H.	Fair	Nil	10.6.29 spraying (96 trees). 16.1.30 spraying (300 trees).
7*c*	16.1.30	3- 7 M.P.H.	Fair	Nil	431 bush apples (planted 15 x 15ft.), 15 standard Blaisdon plums. Height and spread of apples vary about 17ft. x 16ft. to 8ft. x 6 ft.; a representative average of all being about 9ft. x 8½ft. Blaisdon plums average about 16ft. high, 10ft. spread. Pruning not done by spraying time. 2 2/3 acres.
	17.1.30	Ditto			
8*a*	23.4.29	1- 7 M.P.H.	Fine	Nil	363 bush apples (planted 15 x 15ft.) average height 10ft., spread 11ft. approx.
	24.4.29	Ditto			Pruning consists of thinning only; complete. One-half the trees very dense
	8.5.29	8-24 M.P.H. (gusty)	Fine	Nil	(Allington). Remainder fairly open. (Edward VII). Area 2 acres approx.
	29.1.30	Calm	Fine	Nil	
10	16.4.29	13-18 M.P.H.	Fine	Nil	213 ½-standard plum trees of approx. average height, 11ft., spread 13ft.
	18.1.30	4-18 M.P.H. (gusty)	Fine	Nil	1½ acres.
11 & 11*a*	18.1.30	4-18 M.P.H. (gusty)		Nil	
	20.1.30	4- 6 M.P.H.	Fine	Nil	340 bush apples 7 years. 374 bush pears 7 years. Area 2 acres approx.
14 & 15	15.4.29	13-18 M.P.H.	Fine	Nil	480 bush apples 4 years. 2,945 black currants. Area 2½ acres approx.
	10.8.29	1- 7 M.P.H. (calm)	.06″	Nil	
	12.8.29	4- 7 M.P.H.	Fine	Nil	
	20.1.30	3- 6 M.P.H.	Fine	Nil	
20	21.1.30	3- 6 M.P.H.	Fine	Nil	Nursery of standard trees mainly just headed at about 6ft. 4,855 trees
	22.1.30	Ditto			planted 4ft. x 2.3ft. About 1 acre. Very awkward shape.
Hillside	7.2.30	13-38 M.P.H.	Nil	Nil	Standard apples 36 x 36ft. 197 trees., from 5-11 years old, in grass.

Table II.

SPRAYING COSTS.

Plot No.	Machine.	No. guns or nozzles.	Spray Fluid.	Galls. Used.	Cost of Concentrate.	Spraying Man Hrs.	Attendant Man Hrs.	Layout Man Hrs.	Cost at 10d.	Cost Engine Fuel approx	Nett Cost.	Water Carting Cost.	Tractor or Haulage Cost.	Waste Time. Hrs.	Waste Time. Cost.	Gross Cost.	Nett per Tree or Bush.	Gross per Tree or Bush.	Nett Total for all Sprayings. (Routine).
					£ s. d.				£ s. d.	s. d.	£ s. d.	£ s. d.	s. d.		s. d.	£ s. d.	d.	d.	
1	Power	3 G	L.A. 6%	1400	6 6 0	17½	7½	8	1 7 6	2 3	7 15 9	1 11 2	1 6	—	—	9 9 5	7.4	9.1	—
2	,,	3 G	Carbo 5%	625	3 10 0	12	5	3	16 8	1 0	4 7 8	10 2	2 3	—	12 5	5 0 1	—	—	—
4*a*	Knapsack	2 N	Lime Sulphur (1-12)	100	13 0	17	–	–	14 2	—	1 7 2	—	—	5	4 6	1 11 8	.19	.23	—
	Power	2 G	Bordeaux (2-4-50)	650	13 0	16	8	3	1 2 6	1 0	1 16 6	16 8	—	—	—	2 13 2	.27	.38	—
	,,	2 G	Carbo 5%	180	1 0 3	4	2	1	5 10	3	1 6 1	3 8	—	—	—	1 9 9	.19	.21	.65d. per bush.
6	,,	3 G	L.A. 6%	230	2 0 0	4½	2	1½	6 6	4	2 6 10	2 9	1 5	—	—	2 10 0	.5	.54	.5d. per bush.
7*b*	,,	2 G									1 2 6	—	—	—	—	1 5 3	1.5	1.6	
	,,										16 7	—	—	—	—	1 2 6	1.0	1.3	
	,,	1 G	Expt.	250	Expt.	3¾	3¾	1	7 1	4	7 5	1 4	8	—	—	9 5	.9	1.2	
	,,	4 G	L.A. 6%	630	4 15 0	8	3	3	11 8	10	5 7 6	14 0	8	—	—	6 2 2	4.3	4.9	6.8d. per tree for routine spraying.
7*c*	,,	4 G	L.A. 6%	1000	7 10 0	13	5	2	18 0	2 0	8 8 9	1 8 0	8	1½	1 3	9 18 8	4.5	5.3	
8*a*	,,	2 G	L.S. 1-60	760	1 1 6	9	4½	3	13 9	1 6	1 16 9	8 3	—	3	2 6	2 7 6	1.2	1.6	
	,,	3 G		1200		12¾					2 12 2	—	—	—	—	3 3 4	1.9	—	
	,,	4 G	L.A. 6%	575	2 3 2	9½	4	3½	14 2	1 0	2 18 4	1 1 0	—	—	—	3 19 4	1.9	2.6	5d. per tree for routine spraying.
10	,,	3 G	L.S. 1-40	640	1 2 8	7½	2½	2	10 0	9	1 12 5	5 6	—	½	5	1 18 4	1.9	2.2	
	,,	4 G	L.A. 6%	525	4 0 0	6	3	3	10 0	1 0	4 11 0	9 2	—	—	—	5 0 2	5.1	5.6	7d. per tree.
11 & 11*a*	,,	4 G	L.A. 6%	550	4 3 0	7¾	4½	4	13 7	1 0	4 17 7	13 6	—	—	—	5 11 1	1.6	1.9	—
14 & 15	,,	3 G	L.S. 1-12	1000	7 0 0	20	7½	5	1 7 1	1 6	8 8 7	15 7	8	—	—	9 4 10	.76	.84	
	,,	3 G	Bordeaux (2-4-50)	1150	1 5 0	18	6	3	1 2 6	1 9	2 9 3	14 8	—	—	—	3 3 11	.27	.34	
	,,	4 G	L.A. 6%	550	4 3 0	7½	3½	2½	11 3	9	4 15 0	11 0	—	—	—	5 16 0	.5	.6	1.5d. per bush.
20	,,	4 G	L.A. 6%	625	3 10 0	8½	2	2	12 6	1 0	4 3 6	13 10	—	—	—	4 17 4	.2	.25	—
Hillside	Knapsack	2 N	L.A. 6%	100	15 0	9	4	–	10 10		1 5 10	2 9	—	—	—	1 8 7	1.5	1.7	—

L.A. = Long Ashton Two-Solution Winter Wash.
L.S. = Lime Sulphur.

CIDER MAKING TRIALS FOR THE SEASON 1928-29.

By O. Grove.

The 1928 cider apple crop was a very good one and the yield was above the average in most districts. In respect of quality the apples were very fair, the average specific gravity of the juices from all the samples examined at the Institute being 1.0528.

It was also a good year for perry pears, for both crop and quality of fruit and the perries produced were of outstanding quality.

The Cider and Perry Competitions.

For the fourth year in succession the chief item in the cider-making programme was a competition arranged on similar lines to those described in reports for 1926, 1927 and 1928.

176 entries of fruit were received. The fruit was stored until judged to be fit for milling, and the subsequent treatment given to each cider was the same except for the following differences as to the filtration period. In Classes I and II the ciders were filtered when the specific gravity of the fermenting juice was 1.028 ; in Class III, 1.030 ; in Class IV, 1.020 ; and in Classes V and VI, 1.025.

Details of the entries will be found in Table I below.

The competition was open to growers residing in the counties of Devon, Dorset, Gloucester, Hereford, Monmouth, Somerset and Worcester. The entries from the different counties were distributed as follows :—Devon 23, Dorset 6, Gloucester 39, Hereford 16, Monmouth 14, Somerset 58 and Worcester 20.

The ciders and perries were judged on April 18th and 19th, 1929, by Messrs. S. Weston, Much Marcle, Hereford ; John H. Wootton, Byford, Hereford ; and W. D. McCreath, North Petherton, Somerset.

Class I, Kingston Black, was a good class. The five exhibits gaining places in the awards list were of high quality and typical samples of this excellent variety.

Class II, which was limited to seven special varieties, was an innovation introduced to meet a point of criticism of the scheme which had been raised at various times by individual members of the Organising Committee of the scheme. It was urged that in each " single-variety " class open to any variety possessing the required characters it usually happened that the principal awards went to one or two varieties in each class, *e.g.* Sweet Alford in the " sweet " class. The seven selected varieties referred to were therefore barred from entry in the " sharp," " sweet " and " bitter-sweet " variety classes concerned and were grouped together to form an entirely new class of composite character. Each of the seven owed its selection to its more or less outstanding merit as a vintage variety in its particular class. The number of sorts included was extended to seven, so that each county in the Scheme could be represented through at least one of the chosen sorts. As will be seen below in the judge's report, this class was not considered very satisfactory from the judging point of view and will be discontinued in future competitions.

With regard to the single entries, the two Fredericks, Nos. 9 and 13, were good samples of this valuable sharp variety, although the acidity of No. 9 was unusually high. No. 10, Foxwhelp, was a little coarse in flavour. Of the four Sweet Alfords in the Class No. 18 was the best. Nos. 14 and 15, Stoke Red, were both good samples of this very promising variety ; in the last one the bitter character was a little too pronounced. No. 17, Cowarne Red, produced an excellent cider, and No. 19, Golden Ball, a Dorset variety, gave a very acceptable medium sharp cider.

In Class III, No. 20, Breakwell's Seedling, has been tried before, and cannot be recommended as a variety attaining the required modern standard. No. 21, Red Streak, gave a sharp cider of good quality. No. 22, White Sweet—which, in spite of its local name, is a sharp variety—was only fair. No. 23, Golden Ball, a Monmouth variety not to be confused with the apple of the same name in Class II, produced a cider of no great value, which fermented rather too quickly. No. 24, Wagstaff, gave a cider of undoubted quality with pronounced acidity. No. 25, Admiral Rodney, and No. 26, Firey Faces, both tried for the first time, produced ciders of inferior quality. No. 27, Cap of Liberty, was an excellent cider typical of this outstanding sharp variety. No. 28, Never Blight, was of fair quality and No. 29, Dymock Red, gave a cider of high value. The next four in the list, Bastard Tom Putt, Cowsden Green, King of the Orchard and Broadtails, of which the second and the last were tried for the first time, did not produce ciders of

much merit. No. 24, Dymock Red, gave a cider of good quality. No. 35, Sour Natural, was fair, but rather low in acidity for the class. No. 36, Maiden Blush, was tried for the first time; the cider was only fair and fermented too rapidly. No. 37, Pages Yellow, was a good cider, better than No. 38, Red Dymock, which was only moderate in character. No. 39, Price's Kernel, was very acceptable, but rather sweet for the class. No. 40, Sour Cluster, gave a cider of good quality. The two next, Lambrook Pippin, were not quite up to the normal standard of this variety. No. 43, Cowsden Red, was not very good and fermented too rapidly. No. 44, Toogood Bitter, was good, with a nice aroma. No. 45, King Manning, tried for the first time, was of medium standard only. No. 46, Lambrook Beauty, also a newcomer, was of similar value. No. 47, Jones' Sharp, was rather inferior and too rapidly fermenting. No. 48, Brandy Red Streak, tried for the first time, gave a very desirable slow fermentation, but the cider was not very good. No. 49, Green Styre, and No. 50, Never Blight, were both somewhat inferior in character. No. 51, Woolston Spice, was fair. Nos. 52, 53 and 54, all tried for the first time, were not of high value. No. 55, Lambrook Pippin was a good cider. No. 56 was only fair.

In Class IV, for Sweet Varieties, the general standard of the samples was not very high. No. 57, Large Hangdown and No. 58, Wyatt's Seedling, were ciders of moderate value only. No. 59, Court Royal, was fair, but fermented too quickly. The same was the case with No. 60, Sweet Bramley, which was tried for the first time and gave a cider of no great value. No. 61, Wyatt's Sweet, produced a moderately good cider; decidedly better was No. 62, Shapwick Sweet, tried for the first time; No. 63, Perthyre, was rather inferior for the variety; the fruit was not in good condition when received. No. 64, White Jersey, was fair, and No. 65, Improved Pound gave a better cider than usual for the variety. No. 66, Berkeley Pippin, was a useful cider, and No. 67, Pear Pine, tried for the first time, was good, but fermented much too rapidly. Nos. 68 and 69, Woodbine and Cadbury, gave very fair ciders, but not up to the standard of No. 70, Woodbine, which was the best cider in the class. No. 71, Nunnington Morgan Sweet, sent in under the name of Morgan Sweet, was not identical with that variety; it produced a cider of quite fair quality. No. 72, Wyatt's Seedling, gave a very good sweet cider.

Class V, for Bittersweet Varieties, was upon the whole a good class, with the bitter character well marked in most cases. The first five, No. 73 to No. 77, have all been tried before and were well

up to their usual standard. No. 78, Stoke Beauty and No. 79, Yellow Crab, both tried for the first time, gave only fair ciders; the last named had a rather high rate of fermentation. Nos. 80, 81 and 82, all well known varieties, were above their usual standard. No. 83, Red Bittersweet, not tried before, produced a cider of medium value only. No. 84, Dove, was a fairly good cider, much better than No. 85, Fillbarrel, which was not of high quality. No. 86, Red Jersey, produced a very good cider; No. 87 was rather inferior. No. 88, Knotted Kernel, was an excellent cider. No. 89, Dabinett, was not quite so good as usual for this variety. No. 90 was not very good. Of the rest, Nos. 91 and 95 were very good ciders. Nos. 92, 94, 97 and 99 rather inferior. Nos. 93 and 96, the last tried for the first time, were very fair ciders, and No. 98, Middle Mead, also tried for the first time, was a cider of good quality.

In Class VI, for Mixed Varieties, the blending of the different varieties in the entries, as usual in this class, showed room for improvement. In many cases the sharp flavour was too pronounced; in others there was too much of the bitter character. Nevertheless, as a whole, they were a very fair lot, decidedly better than last year's samples. As an instance of a sample with a much too high acidity, No. 105 with 1.31% of malic acid, may be quoted. Too low acidity is represented by No. 103 with 0.23% of acid. When it is taken into consideration that the best ciders generally have acidities varying from 0.3% to 0.6% it will be seen that much better results could have been obtained in the two cases given if the blending of the varieties had been better adjusted. Most of the samples selected by the Judges for awards had an acidity of below 0.4%; only one, No. 111, contained more than 0.4% of malic acid.

Class VII, the Perry Class, was exceptionally good. Out of six Oldfield entries four took the four prizes available and the fifth was very highly commended. The Butt Perries were also of good standing, but perries made from this variety generally suffer from too much astringency. The Blakeney Red Perries were exceptionally good for the variety. Of the Barlands, No. 146 was the best, the others were only of moderate quality. Of varieties tried for the first time No. 136, Betty Prosser, gave a perry of good quality and the same may be said of No. 138, Squash Pear. No. 143, Aylton Red, was also a good perry with a delicate flavour. No. 145, Runny Bobs, was rather inferior and too sharp in flavour; it also fermented too quickly. No. 156, Red Horse pear, gave a perry of very fair quality. No. 162, Longdon, was not quite so good, and No. 164, Dymock Red, was of inferior quality.

Report of Judges

on the Long Ashton Cider Competitions 1928-29.

In order that the awards in these Competitions might be announced on the Annual Tasting Day, the entries were judged on Thursday, April 18th, and Friday, April 19th. Notwithstanding the severe and very late winter, which might have been expected to cause the ciders to be even more than usually immature at the time of judging, they were as a whole well forward in condition. Probably no single entry suffered from lack of condition sufficiently to affect the awards list.

The number of ciders and perries in the Competitions was 176, only four less than the record entry of last year. The seven classes among which they were divided and the number of entries in each were as follows :—

		No. of Entries.
Class I.	For Kingston Black variety only	8
„ II.	„ any of the following varieties of apples : Sweet Alford Stoke Red, Cowarne Red, Eggleton Styre, Frederick, Foxwhelp and Golden Ball	11
„ III.	„ any other single varieties of the Sharp class	37
„ IV.	„ „ „ „ „ Sweet „	16
„ V.	„ „ „ „ „ Bitter-sweet class ..	27
„ VI.	„ mixed varieties	36
„ VII.	„ any single variety of Perry Pear	41
	Total	176

The 8 entries in Class I, the Kingston Black class, were a good and very level lot, quite characteristic of the variety. There was little to choose between those gaining awards. None were outstandingly good. The average acidity was slightly below the usual and the colour satisfactory, although rather paler than in some seasons.

Class II was a new class, tried for the first time. It was limited to entries of any of seven of the leading varieties of vintage merit, three of them sweet and the other four sharp varieties. A class of this description is most difficult to judge satisfactorily on account of the great differences in type which are bound to occur among the entries. It should be explained that in making the awards in this case the entries were judged on the following basis. It was assumed that each variety could be regarded as having approximately equal vintage value and that what was required was a comparison of the quality of the individual entry against the best standard of its

variety. Thus, for example, the Sweet Alford entries were judged on their merits as Sweet Alfords, the Fredericks as Fredericks, and so on. No attempt was made to assess each entry against a common standard. Such a class really required judges with experience of a kind unlikely to occur in ordinary practice and we have found the task particularly difficult, since none of us are equally familiar with every variety included. The standard of the ciders in the Class was good generally, each entry being very clean and in good condition : but none were sufficiently outstanding to make the selection for awards easy. We would suggest that the Competitions Committee should consider if the objects of this Class could not be attained in some other manner another year.

Class III, for any sharp varieties other than those included in Classes I and II, was a large and good all-round one. The ciders as a whole were clean and in good condition. The first prize entry was of very good quality, and none of the others quite attained the same standard.

Class IV, the corresponding class for sweet varieties, obviously suffered by the transfer of two leading varieties of this type, Sweet Alford and Eggleton Styre, to Class II. The quality generally was not high, although condition as a whole was good. The first-prize-winner was distinctly superior to the remainder and was a very useful cider.

The bitter-sweet class (Class V) contained many entries of a remarkably level and similar character. A regular feature throughout was a distinctive bitterness, which appears to be characteristic for the season. The quality and condition were good generally and special mention may be made of the first prize winner.

Class VI, that for blends of varieties, was as expected the most variable in quality. Instances where the ciders were too acid or too bitter, although good otherwise, were frequent and it is evident that the art of blending has still to be learnt by many of the competitors. The first and second prizewinners were very good and some others deserve commendation : but many gave the impression that the fruit used was capable of much better results, had the balance of the blend been better adjusted.

The last class (Class VII), that for perry, was noteworthy for its size, but even more remarkable for its quality. In the whole of our experience we have never before met with a class of perries in which the standard was so uniformly high. It is doubtful if so strong a class has ever been previously assembled. In both flavour, condition and general quality the entries generally were exceptionally

good, even though none perhaps have quite attained the superlative standard which sometimes crops up in isolated cases in the outstanding vintage years. None the less the class included many examples of perries of the best quality and is likely to be long remembered. The task of allocating the awards was very difficult and there were many entries not in the prize list which would win easily in an average year.

In conclusion we feel that special reference should be made to the manner in which the ciders and perries have been prepared in these Competitions. The very large number of entries must have thrown a heavy strain on the cider-house staff of the Institute to get the making and subsequent treatment completed under conditions equally fair for all entries. Their task was rendered even more difficult because of the congestion in the making operations due to rapid and comparatively early ripening of even the later varieties of the fruit, to the indifferent keeping quality of the 1928 crop, and to the difficult weather conditions over the whole cider making period. That so little sign of taint of any kind is detectable in the samples is a striking tribute to the energy and skill of the Staff and they deserve to be warmly congratulated on the results of their efforts.

The Institute authorities in turn may view with satisfaction the established success of the Competition Scheme, which bids fair to go far towards achieving the important objects for which it was started.

Signed S. Weston.

John H. Wootton.

W. D. McCreath.

TABLE 1.

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1929.	Name and Address of Grower.
	CLASS 1.—Kingston Blacks—									
1	Kingston Black ..	8/11/28	1.062	0.69	0.19	6.7	3/12/28	1.028	1.024	R. J. Wear, Congresbury, Som.
2	„ „ ..	8/11/28	1.053	0.53	0.17	4.7	28/12/28	1.028	1.027	J. E. Edwards, Norton Canon, Hereford.
3	„ „ ..	8/11/28	1.061	0.65	0.19	6.0	6/12/28	1.028	1.028	W. Wyatt, Kingweston, Som.
4	„ „ ..	8/11/28	1.054	0.50	0.18	5.0	10/12/28	1.028	1.028	G. E. Tyley, Cheddar, Som.
5	„ „ ..	8/11/28	1.060	0.57	0.18	5.0	20/12/28	1.028	1.028	J. Maunder, Kingweston, Som.
6	„ „ ..	8/11/28	1.056	0.52	0.18	3.2	6/2/29	1.028	1.028	R. J. Denning, Ilminster, Som.
7	„ „ ..	8/11/28	1.057	0.57	0.19	4.2	4/2/29	1.028	1.028	H. E. Dabinett, Somerton, Som.
8	„ „ ..	19/11/28	1.062	0.48	0.17	3.1	8/4/29	1.028	1.026	W. Hill, Kittisford, Som.
	CLASS 2.—(The following varieties only : Sweet Alford, Stoke Red, Eggleton Styre, Frederick, Foxwhelp, and Golden Ball)—									
9	Frederick	11/10/28	1.058	1.27	0.12	5.7	30/10/28	1.028	1.028	G. Breakwell, Perthyre, Mon.
10	Foxwhelp	12/10/28	1.053	0.90	0.26	5.6	30/10/28	1.028	1.026	W. Ridley Thomas, Nunnington, Her.
11	Sweet Alford ..	22/10/28	1.057	0.36	0.13	4.1	8/11/28	1.028	1.025	J Peck, Ottery St. Mary, Devon.
12	Sweet Alford ..	24/10/28	1.057	0.34	0.16	3.5	26/11/28	1.028	1 025	H. L. J. Horrell, Stoke Canon, Devon.
13	Frederick	29/10/28	1.060	1.06	0.10	4.2	21/12/28	1.028	1.028	S. W. Mullins, Raglan, Mon.
14	Stoke Red	29/10/28	1.041	0.59	0.19	2.0	12/11/28	1.028	1.025	W. J. Tyley, Rodney Stoke, Som.
15	Stoke Red	30/10/28	1.054	0.64	0.32	4.0	28/11/28	1.028	1.027	H. H. Sealy, Rodney Stoke, Som.
16	Sweet Alford ..	2/11/28	1.054	0.25	0.15	4.3	18/12/28	1.028	1.027	F. E. Salter, Crediton, Devon.
17	Cowarne Red ..	12/11/28	1.048	0.75	0.13	3.5	5/12/28	1.028	1.026	W. P. Merrett, Arlingham, Glos.
18	Sweet Alford ..	23/11/28	1.054	0.30	0.13	2.0	13/3/29	1.028	1.027	W. J. Berry, Newton St. Cyres, Devon.
19	Golden Ball ..	9/11/28	1.047	0.54	0.16	4.2	24/11/28	1.028	1.028	J. Bowditch, Stoke Abbott, Dorset.

TABLE I.—*continued.*

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1929.	Name and Address of Grower.
	CLASS 3.—Sharp Varieties—									
20	Breakwell's Seedling	11/10/28	1.045	0.62	0.20	3.0	26/10/28	1.030	1.029	G. Breakwell, Perthyre, Mon.
21	Red Streak ..	22/10/28	1.056	0.96	0.22	4.7	12/11/28	1.030	1.028	H. Knight, Huntley, Glos.
22	White Sweet ..	22/10/28	1.050	0.65	0.11	3.4	16/11/28	1.030	1.029	W. Hunt, Easton-in-Gordano, Som.
23	Golden Ball ..	29/10/28	1.048	0.47	0.10	3.5	13/11/28	1.030	1.028	S. W. Mullins, Raglan, Mon.
24	Wagstaff	29/10/28	1.058	0.84	0.15	4.0	21/11/28	1.030	1.028	P. E. Bomford, Upton Snodsbury, Wor.
25	Admiral Rodney ..	29/10/28	1.043	0.69	0.14	2.0	12/11/28	1.030	1.028	W. J. Tyley, Rodney Stoke, Som.
26	Firey Faces ..	29/10/28	1.059	0.78	0.15	7.5	12/11/28	1.030	1.021	P. E. Bomford, Upton Snodsbury, Wor.
27	Cap of Liberty ..	30/10/28	1.061	1.10	0.28	3.8	11/2/29	1.030	1.030	E. Hodges, Martock, Som.
28	Never Blight ..	30/10/28	1.051	0.63	0.20	3.6	27/11/28	1.030	1.029	H. C. Jennings, Shapwick, Som.
29	Dymock Red ..	30/10/28	1.055	0.55	0.22	4.2	29/11/28	1.030	1.030	Taylor Bros., Dymock, Glos.
30	Bastard Tom Putt..	31/10/28	1.048	0.82	0.16	2.7	22/11/28	1.030	1.028	W. Hunt, Easton-in-Gordano, Som.
31	Cowsden Green ..	31/10/28	1.053	0.61	0.15	3.5	15/11/28	1.030	1.029	P. E. Bomford, Upton Snodsbury, Wor.
32	King of the Orchard	2/11/28	1.053	0.65	0.15	7.0	19/11/28	1.030	1.030	S. W. Mullins, Raglan, Mon.
33	Broadtails	2/11/28	1.059	0.86	0.16	6.0	27/11/28	1.030	1.030	T. R. Price, Westhide, Her.
34	Dymock Red ..	2/11/28	1.059	0.65	0.24	6.3	23/11/28	1.030	1.028	R. E. Turner, Dymock, Glos.
35	Sour Natural ..	2/11/28	1.046	0.46	0.12	5.3	21/11/28	1.030	1.027	J. Halse & Son, Newton St. Cyres, Devon.
36	Maiden Blush ..	5/11/28	1.055	0.86	0.12	7.7	21/11/28	1.030	1.026	S. F. Cowles, Westbury-on-Severn, Glos.
37	Pages Yellow ..	5/11/28	1.052	0.67	0.13	6.6	24/11/28	1.030	1.026	Rt. Hon. Lord Bledisloe, Lydney, Glos.
38	Red Dymock ..	7/11/28	1.056	0.51	0.25	6.7	22/11/28	1.030	1.025	W. Weavers, Shrawley, Wor.
39	Price's Kernel ..	8/11/28	1.052	0.46	0.13	7.5	22/11/28	1.030	1.028	H. A. Lane, Chaceley, Wor.
40	Sour Cluster ..	9/11/28	1.050	0.62	0.19	5.7	1/12/28	1.030	1.029	S. F. J. Clarke, Honiton, Devon
41	Lambrook Pippin ..	9/11/28	1.052	0.57	0.24	4.5	3/12/28	1.030	1.028	W. Wyatt, Kingsweston, Som.
42	Lambrook Pippin ..	9/11/28	1.041	0.54	0.18	4.0	26/11/28	1.030	1.022	R. J. Denning, Ilminster, Som.

CLASS 3.—SHARP VARIETIES—*contd.*

43	Cowsden Red ..	9/11/28	1.050	0.58	0.11	5.0	21/11/28	1.030	1.019	P. E. Bomford, Upton Snodsbury, Wor.
44	Toogood Bitter ..	9/11/28	1.048	0.65	0.21	5.7	24/11/28	1.030	1.027	G. E. Tyley, Cheddar, Som.
45	King Manning ..	12/11/28	1.048	0.79	0.12	5.3	22/11/28	1.030	1.025	A. J. Abbott, Ivybridge, Devon.
46	Lambrook Beauty..	13/11/28	1.050	0.48	0.16	2.6	19/12/28	1.030	1.030	Scott & Gent, East Lambrook, Som.
47	Jones' Sharp ..	13/11/28	1.046	0.63	0.12	4.0	1/12/28	1.030	1.029	D. Jones, St. Mellons, Mon.
48	Brandy Red Streak	13/11/28	1.056	0.61	0.14	3.0	6/3/29	1.030	1.030	H. Hawkins, Brookthorpe, Glos.
49	Green Styre ..	16/11/28	1.054	1.02	0.11	8.3	26/11/28	1.030	1.027	R. E. Turner, Dymock, Glos.
50	Never Bright ..	16/11/28	1.049	0.54	0.15	5.3	26/11/28	1.030	1.029	S. H. Osborn, North Cadbury, Som.
51	Woolston Spice ..	16/11/28	1.045	0.55	0.11	5.3	26/11/28	1.030	1.028	„ „ „
52	Nonsuch	22/11/28	1.057	0.65	0.13	7.0	5/12/28	1.030	1.021	Clinch & Goddard, Upton-on-Severn, Wor.
53	Smokers	22/11/28	1.055	0.64	0.21	5.7	11/12/28	1.030	1.029	„ „ „ „ „
54	Ironside	23/11/28	1.053	0.77	0.22	4.7	15/12/28	1.030	1.030	E. C. Smith, Stoke Abbott, Dorset.
55	Lambrook Pippin ..	28/11/28	1.051	0.57	0.25	2.7	31/12/28	1.030	1.030	J. Maunder, Kingweston, Som.
56	Hartisman	28/11/28	1.041	0.65	0.15	4.0	11/12/28	1.030	1.028	W. Hunt, Easton-in-Gordano, Som.

CLASS 4.—SWEET VARIETIES—

57	Large Hangdown ..	22/10/28	1.055	0.22	0.18	4.7	20/11/28	1.020	1.017	R. Collins, Chagford, Devon.
58	Wyatt's Seedling ..	22/10/28	1.046	0.40	0.13	4.5	7/11/28	1.020	1.018	H. S. Beedell, Thorverton, Devon.
59	Court Royal ..	23/10/28	1.049	0.23	0.12	6.6	2/11/28	1.020	1.016	H. C. Swearse, Cheddar, Som.
60	Sweet Bramley ..	24/10/28	1.054	0.26	0.16	6.5	7/11/28	1.020	1.014	J. W. Hussey, Cullompton, Devon.
61	Wyatt's Sweet ..	24/10/28	1.055	0.22	0.16	4.7	14/11/28	1.020	1.017	W. Wyatt, Kingweston, Som.
62	Shapwick's Sweet ..	30/10/28	1.055	0.30	0.16	4.8	3/12/28	1.020	1.020	H. C. Jennings, Shapwick, Som.
63	Perthyres	2 11/28	1.051	0.34	0.18	7.3	24/11/28	1.020	1.018	S. W. Mullins, Raglan, Mon.
64	White Jersey ..	5/11/28	1.048	0.34	0.11	4.7	26/11/28	1.020	1.016	J. Maunder, Kingweston, Som.
65	Improved Pound ..	12/11/28	1.056	0.23	0.16	5.6	18/12/28	1.020	1.019	R. M. Read, Nempnett, Som.
66	Berkeley Pippin ..	12/11/28	1.053	0.22	0.12	4.1	19/12/28	1.020	1.019	P. J. Wherrett, Frampton-on-Severn, Glos.
67	Pear Pine	13/11/28	1.045	0.23	0.17	6.8	29/11/28	1.020	1.018	A. J. Abbott, Ivybridge, Devon.
68	Woodbine	13/11/28	1.048	0.22	0.14	4.8	6/12/28	1.020	1.016	R. J. Denning, Ilminster, Som.
69	Cadbury	16/11/28	1.040	0.35	0.15	3.0	7/12/28	1.020	1.017	S. H. Osborn, North Cadbury, Som.
70	Woodbine	19/11/28	1.052	0.22	0.14	4.6	7/2/29	1.020	1.020	W. Hill, Kittisford, Som.
71	Nunnington Morgan Sweet	21/11/28	1.045	0.29	0.15	5.6	7/12/28	1.020	1.018	W. Ridley Thomas, Nunnington, Her.
72	Wyatt's Seedling ..	23/11/28	1.051	0.37	0.17	3.2	11/1/29	1.020	1.019	W. J. Berry, Newton St. Cyres, Devon.

TABLE I.—*continued.*

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1929.	Name and Address of Grower.
	CLASS 5.—Bittersweet Varieties—									
73	Royal George ..	11/10/28	1.051	0.35	0.20	5.5	26/10/28	1.025	1.022	W. Hunt, Easton-in-Gordano, Som.
74	White Norman ..	12/10/28	1.049	0.31	0.24	5.0	27/10/28	1.025	1.019	W. Ridley Thomas, Nunnington, Her.
75	Royal Wilding ..	22/10/28	1.058	0.21	0.23	4.3	16/11/28	1.025	1.024	F. Pole, Holmer, Her.
76	Cummy Norman ..	22/10/28	1.054	0.29	0.20	5.0	9/11/28	1.025	1.024	,, ,, ,,
77	Loyal Drain ..	24/10/28	1.061	0.29	0.40	2.3	4/2/29	1.025	1.023	H. E. Dabinett, Somerton, Som.
78	Stoke Beauty ..	29/10/28	1.049	0.29	0.21	4.3	19/11/28	1.025	1.022	W. J. Tyley, Rodney Stoke, Som.
79	Yellow Crab ..	29/10/28	1.045	0.25	0.22	5.5	12/11/28	1.025	1.019	,, ,, ,,
80	Loyal Drain ..	30/10/28	1.057	0.24	0.37	2.6	13/3/29	1.025	1.025	H. C. Jennings, Shapwick, Som.
81	Devon Bittersweet	2/11/28	1.056	0.37	0.26	5.7	3/12/28	1.025	1.022	H. Kerslake, Landrake, Devon.
82	Broadleaf Jersey ..	2/11/28	1.059	0.28	0.31	5.3	6/12/28	1.025	1.023	W. Wyatt, Kingweston, Som.
83	Red Bittersweet ..	2/11/28	1.056	0.44	0.25	5.7	18/12/28	1.025	1.025	G. W. Voysey, Musbury, Devon.
84	Dove	5/11/28	1.049	0.24	0.24	3.3	2/12/28	1.025	1.025	J. Maunder, Kingweston, Som.
85	Fillbarrel	5/11/28	1.060	0.25	0.31	5.0	11/1/29	1.025	1.025	A. G. Barber, Ditcheat, Som.
86	Red Jersey ..	5/11/28	1.053	0.20	0.31	2.7	13/3/29	1.025	1.025	R. J. Denning, Ilminster, Som.
87	Shrawley White Sw.	7/11/28	1.049	0.43	0.23	6.7	22/11/28	1.025	1.023	W. Weavers, Shrawley, Wor.
88	Knotted Kernel ..	8/11/28	1.052	0.24	0.29	3.7	21/1/29	1.025	1.025	J. E. Edwards, Norton Canon, Her.
89	Dabinett	9/11/28	1.050	0.25	0.25	5.5	27/11/28	1.025	1.023	G. H. Sawtell, Kingsweston, Som.
90	Shrawley Red ..	12/11/28	1.058	0.37	0.31	5.1	7/12/28	1.025	1.024	W. Weavers, Shrawley, Wor.
91	Strawberry Norman	13/11/28	1.055	0.29	0.38	4.2	21/1/29	1.025	1.024	G. H. Chudley, Ipplepen, Devon
92	French	13/11/28	1.053	0.25	0.38	5.4	3/12/28	1.025	1.021	A. L. Thomas, Manson, Mon.
93	Belle Norman ..	13/11/28	1.055	0.26	0.32	4.6	10/12/28	1.025	1.022	J. N. Gwynne, Sutton, Her.
94	Broadleaves ..	13/11/28	1.049	0.27	0.25	8.4	26/11/28	1.025	1.015	R. J. Denning, Ilminster, Som.
95	Stable Jersey ..	13/11/28	1.057	0.26	0.30	5.8	22/12/28	1.025	1.025	G. Look, Shepton Mallet, Som.

	CLASS 5—Bittersweet Varieties—*contd.*									
96	Oak Pints	16/11/28	1.047	0.29	0.27	3.0	3/12/28	1.025	1.023	Mills Bros., Stourport, Wor.
97	Shrawley Bittersweet	16/11/28	1.051	0.34	0.34	4.0	5/12/28	1.025	1.022	W. Weavers, Shrawley, Wor.
98	Middle Mead ..	16/11/28	1.049	0.39	0.25	3.0	22/12/28	1.025	1.024	J. Bowditch, Stoke Abbott, Dorset
99	Dabinett	23/11/28	1.055	0.31	0.28	7.0	10/12/28	1.025	1.024	E. H. Dyke & Son, Wincanton, Som.
	CLASS 6.—Mixed Varieties—									
100	Frederick 8, Breakwell Seedling 7 ..	11/10/28	1.049	0.89	0.17	3.7	6/11/28	1.025	1.024	G. Breakwell, Perthyre, Mon.
101	Crab 2, Cap of Liberty 3, Hawkchurch Sweet 4, Billy Down 1, Bastard Tom Putt 2, Impr. Pound 3 ..	12/10/28	1.054	0.75	0.20	8.3	22/10/28	1.025	1.013	D. J. Greenshield, Hawkchurch, Devon
102	Kingston Black 3, Stoke Red 6, Hagloe Crab 6 ..	19/10/28	1.046	0.51	0.19	6.2	5/11/28	1.025	1.022	W. J. Tyley, Rodney Stoke, Som.
103	Kingston Black 3, Never Deceive Me 5, Round Oak 3, River Apple 1, Vallis 2, Longacre 1 ..	23/10/28	1.051	0.23	0.12	5.0	8/11/28	1.025	1.022	H. C. Swearse, Cheddar, Som.
104	White Jersey 5, Port Wine Jersey 1, Cadbury 4, Red Jersey 2, Never Blight 3 ..	23/10/28	1.053	0.25	0.16	4.6	14/11/28	1.025	1.023	S. W. Golledge, Ditcheat, Som.
105	Best Bache 5, Dymock Red 5, Foxley 5	24/10/28	1.055	1.31	0.24	6.2	9/11/28	1.025	1.022	H. G. Ricketts, Dymock, Glos.
106	Sweet Bramley 2, Sweet Alford 5, Sweet Tom Putt 2, Pound Apple 2, Sour Russet 1, Brice's Perfection 2, Crimson Rose 1 ..	24/10/28	1.055	0.25	0.14	4.2	16/11/28	1.025	1.024	J. W. Hussey, Cullompton, Devon.

TABLE I—*continued.*

COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1929.	Name and Address of Grower.
	CLASS 6—Mixed Varieties—*contd.*									
107	Kingston Black 5, White Sweet 6, Chisel Jersey 4	30/10/28	1.044	0.57	0.13	3.0	17/11/28	1.025	1.024	W. Hunt, Easton-in-Gordano, Som.
108	Royal Wilding 6, Kingston Black 1, Red Streak 6, Cowarne Red 2 ..	30/10/28	1.055	0.87	0.20	6.2	20/11/28	1.025	1.023	H. Knight, Huntley, Glos.
109	Kingston Black 5, Sour Hangdown 2, Dabinett 4, Sweet Hangdown 4 ..	30/10/28	1.059	0.58	0.20	3.6	7/1/29	1.025	1.025	H. C. Jennings, Shapwick, Som.
110	Dove 6, Striped Norman 1, Sheep's Nose 2, Jack Say 3, Cap of Liberty 1, Cadbury 1, Lambrook Pippin 1	31/10/28	1.057	0.51	0.23	6.7	17/11/28	1.025	1.020	G. H. Sawtell, Kingweston, Som.
111	Pocket Apple 5, Kingstone Bitter 3, Sweet Alford 2, Brown's Apple 5	31/10/28	1.058	0.59	0.22	2.5	21/1/29	1.025	1.025	E. J. Hill, Staverton, Devon.
112	Woodbine 5, Devon Bittersweet 5, Fair Maid of Devon 5 ..	31/10/28	1.057	0.43	0.16	4.7	27/11/28	1.025	1.023	H. Kerslake, Landrake, Devon.

CLASS 6.—Mixed Varieties—*contd.*

113	White Close Pippin 3, Dove 3, Jersey 3, Two Seedlings 6 ..	31/10/28	1.060	0.44	0.24	5.2	23/11/28	1.025	1.022	W. Wyatt, Kingweston, Som.
114	Cap of Liberty 3, Broad Leaf Norman 8, Kingston Black 1, Lambrook Pippin 3	31/10/28	1.055	0.53	0.24	3.2	27/11/28	1.025	1.023	J. Maunder, Kingweston, Som.
115	White George 3, Kingston Black 4, Berkeley Pippin 3, Hangdown 3, Striped George 2	31/10/28	1.055	0.66	0.18	4.7	22/11/28	1.025	1.023	R. J. Wear, Congresbury, Som.
116	Frederick 5, Golden Ball 3, Sweet Alford 4, Perthyres 3 ..	2/11/28	1.053	0.72	0.14	6.0	4/12/28	1.025	1.024	S. W. Mullins, Raglan, Mon.
117	Eggleton Styre 3, Cap of Liberty 3, Dymock Red 3, Green Styre 3, Improved Pound 3	2/11/28	1.055	0.73	0.17	7.7	19/11/28	1.025	1.023	R. E. Turner, Dymock, Glos.
118	Sour Natural 8, Sweet Alford 4, Norton Bitter 3	2/11/28	1.051	0.32	0.13	4.3	11/12/28	1.025	1.025	J. Halse & Son, Newton St. Cyres, Devon.
119	Red Bitter 4, Pound Apple 6, Red House 5	2/11/28	1.053	0.49	0.18	5.7	14/11/28	1.025	1.024	G. W. Voysey, Musbury, Devon.
120	Winter Quarrenden 6, King Apples 4, Price's Kernel 5 ..	5/11/28	1.045	0.36	0.12	6.0	22/11/28	1.025	1.022	Rt. Hon. Lord Bledisloe, Lydney, Glos.
121	Coccagee 6, Golden Ball 9	5/11/28	1.048	0.58	0.18	3.6	27/12/28	1.025	1.024	J. Bowditch, Stoke Abbott, Dorset.
122	Green Styre 4, Oak Pin 4, Red Streak 3, White Norman 4 ..	7/11/28	1.051	0.88	0.13	9.0	21/11/28	1.025	1.015	W. Weavers, Shrawley, Wor.

TABLE I—*continued.*

CIDERS. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1929.	Name and Address of Grower.
	CLASS 6.—Mixed Varieities—*contd.*									
123	Kingston Black 4, Cap of Liberty 4, Maynard's Bittersweet 4, Maynard's Sweet 3	8/11/28	1.059	0.53	0.22	5.5	3/12/28	1.025	1.021	W. Maynard, Martock, Som.
124	Woodbine 2, Improved Pound 2, Pound Apple 5, Bittersweet 1, Somersets 2, Sour Cluster 3	9/11/28	1.056	0.50	0.19	7.2	30/11/28	1.025	1.024	S. F. J. Clarke, Honiton, Devon.
125	Royal Jersey 1, Cadbury 3, Cap of Liberty 3, Hangdown 5, Harry Masters 3 ..	9/11/28	1.058	0.42	0.22	6.5	3/12/28	1.025	1.024	T. H. Golledge, Shepton Mallet, Som.
126	Hook Street 6, Yellow Styre 4, Nicholl's Kernel 5	9/11/28	1.059	0.56	0.18	6.7	27/11/28	1.025	1.021	R. J. Wherrett, Frampton-on-Severn, Glos.
127	Strawberry Norman 3, Kill Boy ½, Foxwhelps ½, Knotted Kernel 1, Kingston Black 3, Eggleton Styre 7	9/11/28	1.063	0.39	0.20	7.0	8/12/28	1.025	1.024	J. P. Eley, Frampton Cotterell, Glos.

CLASS 6.—Mixed Varieties—*contd.*

128	Sweet Alford 3, Hangdown 3, Bittersweet 3, Normans 3, Strode Red Streak 3 ..	9/11/28	1.058	0.37	0.23	5.0	31/12/28	1.025	1.025	B. Pearce, Winford, Som.
129	Cap of Liberty 6, Dove 3, Royal Jersey 2, Yarlington Mill 4	12/11/28	1.053	0.36	0.23	3.3	22/1/29	1.025	1.025	A. G. Barber, Ditcheat, Som.
130	Kingston Black 1, Black Styre 3, Red Styre 3, Cambridge 2, Red Foxwhelp 3, Sugar Pippin 3 ..	12/11/28	1.053	0.61	0.16	3.6	20/12/28	1.025	1.025	G. E. Bubb, Westbury-on-Severn, Glos.
131	Best Bearer 5, Stoke's Bitter 3, Crimson King 4, Somerset Crab 3	12/11/28	1.050	0.50	0.18	5.8	26/11/28	1.025	1.020	E. C. Smith, Stoke Abbott, Dorset
132	Hanplot 6, Somerset Crab 4, Best Bearer 3, Crimson King 2	12/11/28	1.047	0.42	0.15	3.8	3/12/28	1.025	1.022	E. C. Smith, Stoke Abbott, Dorset.
133	Fair Maid 8, Sweet Alford 2, Woodbine 5	12/11/28	1.050	0.46	0.14	4.8	28/11/28	1.025	1.024	F. E. Salter, Crediton, Devon.
134	Kingston Black 5, Cluster 4, Woodbine 6	19/11/28	1.054	0.32	0.15	3.1	31/12/28	1.025	1.025	W. Hill, Kittisford, Som.
135	Kingston Black 5, Stripes 3, White Jersey 2, Norman 2, Kernel 1, Stones 2	23/11/28	1.061	0.56	0.21	6.2	20/12/28	1.025	1.025	Clinch & Goddard, Upton-on-Severn, Wor.

TABLE I.—*continued.*

PERRIES. COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1929.	Name and Address of Grower.
	CLASS 7.—PERRIES—									
136	Betty Prosser ..	9/10/28	1.055	0.60	0.12	4.6	5/11/28	1.030	1.028	A. T. Blake & Son, Monmouth.
137	Blakeney Red ..	9/10/28	1.046	0.44	0.12	2.0	15/11/28	1.030	1.029	A. T. Blake & Son, Monmouth.
138	Squash Pear ..	12/10/28	1.053	0.45	0.14	5.0	31/10/28	1.030	1.030	J. Lloyd, Newent, Glos.
139	Blakeney Red ..	16/10/28	1.057	0.55	0.11	6.2	7/11/28	1.030	1.030	H. Knight, Huntley, Glos.
140	Malvern Hill ..	16/10/28	1.066	0.45	0.19	5.2	3/12/28	1.030	1.030	J. Lloyd, Newent, Glos.
141	Barlow Pear ..	16/10/28	1.055	0.63	0.14	5.0	12/11/28	1.030	1.028	,, ,, ,,
142	Blakeney Red ..	17/10/28	1.046	0.40	0.12	3.0	6/11/28	1.030	1.028	A. L. Thomas, Monmouth.
143	Aylton Red ..	17/10/28	1.052	0.44	0.11	4.2	13/11/28	1.030	1.026	F. Pole, Holmer, Her.
144	Barland	19/10/28	1.052	0.85	0.20	3.5	12/11/28	1.030	1.028	H. Knight, Huntley, Glos.
145	Runny Bobs ..	19/10/28	1.053	0.95	0.11	8.0	7/11/28	1.030	1.028	P. E. Bomford, Upton Snodsbury, Wor.
146	Barland	19/10/28	1.051	0.76	0.16	6.0	12/11/28	1.030	1.025	W. Weavers, Shrawley, Wor.
147	Barnett	19/10/28	1.054	0.43	0.14	5.0	16/11/28	1.030	1.028	H. G. Ricketts, Dymock, Glos.
148	Blakeney Red ..	19/10/28	1.053	0.52	0.11	4.0	14/11/28	1.030	1.028	W. P. Merrett, Arlingham, Glos.
149	Coombe Pear ..	22/10/28	1.053	0.47	0.09	3.7	12/11/28	1.030	1.028	F. G. Ludlow, Westbury-on-Trym, Glos.
150	Oldfield	23/10/28	1.060	0.76	0.23	2.0	26/2/29	1.030	1.029	H. G. Ricketts, Dymock, Glos.
151	Pint Pear	24/10/28	1.050	0.87	0.16	3.7	12/11/28	1.030	1.026	,, ,, ,,
152	Barland	26/10/28	1.048	0.61	0.10	4.7	15/11/28	1.030	1.030	T. R. Price, Westhide, Her.
153	Oldfield	26/10/28	1.060	0.57	0.09	3.3	30/11/28	1.030	1.030	,, ,, ,,
154	Blakeney Red ..	26/10/28	1.055	0.43	0.12	4.0	22/11/28	1.030	1.028	R. Hyett, Dymock, Glos.
155	Blakeney Red ..	26/10/28	1.051	0.40	0.08	3.2	23/11/28	1.030	1.027	C. F. Chapman, Westhide, Her.
156	Red Horse Pear ..	26/10/28	1.052	0.64	0.12	3.6	16/11/28	1.030	1.030	P. E. Bomford, Upton Snodsbury, Wor.
157	Blakeney Red ..	26/10/28	1.044	0.41	0.14	2.7	14/11/28	1.030	1.028	J. Lloyd, Newent, Glos.

CLASS 7.—PERRIES—*contd.*

158	Huff Cap	26/10/28	1.047	0.48	0.13	7.3	2/11/28	1.030	1.020	„ „
159	Blakeney Red ..	26/10/28	1.052	0.44	0.10	2.7	26/11/28	1.030	1.028	S. W. Mullins, Raglan, Mon.
160	Blakeney Red ..	29/10/28	1.052	0.47	0.10	5.5	17/11/28	1.030	1.028	R. E. Turner, Dymock, Glos.
161	Oldfield	30/10/28	1.058	0.59	0.19	4.0	30/1/29	1.030	1.020	F. Pole, Holmer, Her.
162	Longdon	30/10/28	1.054	0.48	0.14	8.0	17/11/28	1.030	1.027	Taylor Bros., Dymock, Glos.
163	Huff Cap	30/10/28	1.046	0.44	0.10	5.5	16/11/28	1.030	1.024	F. Pole, Holmer, Her.
164	Dymock Red ..	30/10/28	1.046	0.31	0.09	2.5	21/11/28	1.030	1.027	J. Lloyd, Newent, Glos.
165	Oldfield	30/10/28	1.061	0.70	0.15	2.2	26/3/29	1.030	1.030	„ „ „
166	Butt	31/10/28	1.058	0.68	0.26	3.2	4/2/29	1.030	1.028	R. Williams, Hardwicke, Glos.
167	Butt	31/10/28	1.057	0.58	0.29	3.2	26/3/29	1.030	1.030	T. A. Rouse, Malvern, Wor.
168	Butt (Blue Clay) ..	5/11/28	1.047	0.38	0.22	2.0	14/1/29	1.030	1.030	J. Fawkes, Leonard Stanley, Glos.
169	Butt	5/11/28	1.056	0.51	0.26	2.0	2/4/29	1.030	1.030	„ „ „ „
170	Butt	5/11/28	1.056	0.58	0.31	1.3	26/3/29	1.030	1.028	S. F. Cowles, Westbury-on-Severn, Glos.
171	Norton Butt ..	8/11/28	1.058	0.61	0.39	4.5	7/2/29	1.030	1.029	G. E. Bubb, Westbury-on-Severn, Glos.
172	Butt	9/11/28	1.058	0.65	0.37	3.7	26/3/29	1.030	1.030	H. A. Lane, Chaceley, Wor.
173	Butt	12/11/28	1.049	0.56	0.23	1.5	30/1/29	1.030	1.030	H. Knight, Huntley, Glos.
174	Oldfield	12/11/28	1.057	0.72	0.10	4.3	1/2/29	1.030	1.030	„ „ „
175	Oldfield	13/11/28	1.058	0.58	0.18	2.0	26/3/29	1.030	1.030	J. N. Gwynne, Sutton, Her.
176	Butt	23/11/28	1.053	0.57	0.25	1.7	7/1/29	1.030	1.028	Clinch & Goddard, Upton-on-Severn, Wor.

TABLE II.

Competition Ciders and Perries, 1928-29.

JUDGES' AWARDS.

Ciders.

Class 1. *No.* Kingston Black. (8 *Entries*).

First Prize	..	8	W. Hill, Kittisford, Som.
Second Prize	..	6	R. J. Denning, Ilminster, Som.
Third Prize	..	5	J. Maunder, Kingweston, Som.
Fourth Prize	..	4	G. E. Tyley, Cheddar, Som.
Reserve Prize	..	2	J. E. Edwards, Norton Canon, Hereford.

Class 2. (The following varieties only: Sweet Alford, Stoke Red, Cowarne Red, Eggleton Styre, Frederick, Foxwhelp and Golden Ball).

		No.	(11 *Entries*).	*Variety.*
First Prize	..	17	W. P. Merrett, Arlingham, Glos.	Cowarne Red.
Second Prize	..	13	S. W. Mullins, Raglan, Mon...	Frederick.
Third Prize	..	18	W. J. Berry, Newton St. Cyres, Devon	Sweet Alford.
Fourth Prize	..	10	W. Ridley Thomas, Nunnington, Hereford	Foxwhelp.
Reserve ..	..	15	H. H. Sealy, Rodney Stoke, Som.	Stoke Red.
Commended	..	19	J. Bowditch, Stoke Abbott, Dorset	Golden Ball.

Class 3. Sharp Varieties. (37 *Entries*).

First Prize	..	27	E. Hodges, Martock, Som. ..	Cap of Liberty.
Second Prize	..	29	Taylor Bros., Dymock, Glos...	Dymock Red.
Third Prize	..	55	J. Maunder, Kingweston, Som.	Lambrook Pippin.
Fourth Prize	..	34	R. E. Turner, Dymock, Glos. ..	Dymock Red.
Reserve ..	..	40	F. J. Clarke, Honiton, Devon..	Sour Cluster.
Highly Commended		24	P. E. Bomford, Upton Snodsbury, Worcs.	Wagstaff.
„ „		37	Rt. Hon. Lord Bledisloe, Lydney	Pages Yellow.
Commended	..	20	G. Breakwell, Perthyre, Mon...	Breakwell's Seedling
„	..	21	H. Knight, Huntley, Glos. ..	Red Streak.
„	..	28	H. C. Jennings, Shapwick, Som.	Never Blight.
„	..	31	P. E. Bomford, Upton Snodsbury, Worcs.	Cowsden Green.
„	..	35	J. Halse & Son, Newton St. Cyres, Devon	Sour Natural.

Class 4. Sweet Varieties. (16 *Entries*).

First Prize	..	70	W. Hill, Kittisford, Som. ..	Woodbine.
Second Prize	..	72	W. J. Berry, Newton St. Cyres, Devon	Wyatt's Seedling.
Third Prize	..	62	H. C. Jennings, Shapwick, Som.	Shapwick Sweet.
Fourth Prize	..	65	R. M. Read, Nempnett, Som.	Improved Pound.
Reserve ..	..	71	W. Ridley Thomas, Nunnington, Hereford	Nunnington Morgan Sweet.

Class 5. BITTERSWEET VARIETIES. (27 *Entries*).

First Prize ..	88	J. E. Edwards, Norton Canon, Hereford	Knotted Kernel.
Second Prize ..	95	G. Look, Shepton Mallet, Som.	Stable Jersey.
Third Prize ..	91	G. H. Chudley. Ipplepen, Devon	Strawberry Norman.
Fourth Prize ..	86	R. J. Denning, Ilminster, Som.	Red Jersey.
Reserve	82	W. Wyatt, Kingweston, Som.	Broadleaf Jersey.
Highly Commended	80	H. C. Jennings, Shapwick, Som.	Loyal Drain.
Commended ..	75	F. Pole, Holmer, Hereford ..	Royal Wilding.
,, ..	76	F. Pole, Holmer, Hereford ..	Cummy Norman.
,, ..	81	H. Kerslake, Landrake, Devon	Devon Bittersweet.
,, ..	84	J. Maunder, Kingweston, Som.	Dove.
,, ..	89	G. H. Sawtell, Kingweston, Som.	Dabinett.
,, ..	93	J. A. Gwynne, Sutton, Hereford	Belle Norman.
,, ..	98	J. Bowditch, Stoke Abbot, Dorset	Middle Mead.

Class 6. MIXED VARIETIES. (36 *Entries*).

First Prize ..	134	W. Hill, Kittisford, Som.
Second Prize ..	111	E. J. Hill, Staverton, Devon.
Third Prize ..	118	J. Halse & Son, Newton St. Cyres, Devon.
Fourth Prize ..	129	A. G. Barber, Ditcheat, Som.
Reserve	128	B. Pearce, Winford, Som.
Highly Commended	135	Clinch & Goddard, Upton-on-Severn, Worcs.
Commended ..	104	S. W. Golledge, Ditcheat, Som.
,, ..	109	H. C. Jennings, Shapwick, Som.
,, ..	116	S. W. Mullins, Raglan, Mon.
,, ..	119	G. W. Voysey, Musbury, Devon.
,, ..	120	Rt. Hon. Lord Bledisloe, Lydney, Glos.
,, ..	121	J. Bowditch, Stoke Abbott, Dorset.
,, ..	123	W. Maynard, Martock, Som.
,, ..	127	J. P. Eley, Frampton Cotterell, Glos.
,, ..	125	T. H. Golledge, Shepton Mallet, Som.

Class 7. PERRIES. (41 *Entries*).

			Variety.
First Prize ..	150	H. G. Ricketts, Dymock, Glos.	Oldfield.
Second Prize ..	153	T. R. Price, Westhide, Hereford	,,
Third Prize ..	161	F. Pole, Holmer, Hereford ..	,,
Fourth Prize ..	165	J. Lloyd, Newent, Glos. ..	,,
Reserve	167	T. A. Rouse, Malvern, Worcs.	Butt.
Very Highly Com'ded	175	J. N. Gwynne, Sutton, Hereford	Oldfield.
Highly Commended	136	A. T. Blake & Son, Monmouth.	Betty Prosser.
,, ,,	138	J. Lloyd, Newent, Glos. ..	Squash Pear.
,, ,,	139	H. Knight, Huntley, Glos. ..	Blakeney Red.
,, ,,	140	J. Lloyd, Newent, Glos. ..	Malvern Hill.
,, ,,	143	F. Pole, Holmer, Hereford ..	Hylton Red.
,, ,,	144	H. Knight, Huntley, Glos. ..	Barland.
,, ,,	146	W. Weavers, Shrawley, Worcs.	,,
,, ,,	155	C. F. Chapman, Westhide, Hereford	Blakeney Red.
,, ,,	156	P. E. Bomford, Upton Snodsbury, Worcs.	Red Horse Pear.
,, ,,	169	J. Fawkes, Leonard Stanley, Glos.	Butt.
,, ,,	173	H. Knight, Huntley, Glos. ..	,,

THE EFFECTS OF LOW TEMPERATURE STORAGE ON CIDER.

By B. T. P. Barker and O. Grove.

It is generally admitted that cider naturally conditioned in bottle is a product of superior quality to the same cider conditioned by carbonation. It has, however, two serious associated drawbacks as a commercial article (*a*) in the gradual formation of a deposit of yeasts and bacteria, which not infrequently becomes unduly heavy and (*b*) in a slow but constant flavour alteration. The extent and rate of these two changes in the condition of the bottled beverage are variable with different ciders, but observations over many seasons with a large variety of ciders, permit the general statement that most kinds when bottled at the usual period in spring for natural conditioning, show signs of flavour deterioration and carry a disfiguring amount of deposit by the following autumn.

The present paper is not concerned with the reasons for the variability of different ciders in these respects. The object of the tests here recorded was to determine if storage at a low temperature would retard deposit formation and flavour deterioration to an extent sufficient to render the cider as marketable during the second year after bottling as in the first.

While the tests were carried out primarily with reference to bottled cider, the results are of wider interest, since ciders in bulk storage are also subject to the same type of flavour change and to the formation of deposit.

In thus investigating the effects of low temperature storage on cider there is no intention of suggesting that cool storage might be necessarily an economic proposition worth consideration for each and every cider at present. Taking into account, however, firstly, that cool storage is rapidly coming into more general use for foodstuffs and is likely to become materially cheaper in future, and, secondly, that no detailed observations on the behaviour of cider at low temperatures have hitherto been recorded, it appeared to the authors that it was desirable that some exact data on the subject should be secured.

Description of Tests and Results.

In May, 1929, bottles of 36 different varieties of cider were placed in a cold store kept at constant temperature at 1 °C. (33.8 °F). At the same time other bottles of the same ciders were kept in the cellar of the cider house at the ordinary cellar temperature (55°-60 °F.) as controls. The samples were subsequently left undisturbed until compared in January, 1930, after eight months storage. The following differences in respect of flavour, colour, acidity, specific gravity and deposit were noted.

Flavour.

It was found almost invariably that the flavour of the cold stored samples was definitely superior : in many cases this superiority was very pronounced. The samples had a fresher, more fruity and aromatic taste than the corresponding ciders kept at ordinary temperature.

In many of the control samples, especially those with an initial acidity of over 0.4%, the characteristic flavour of " old " cider was pronounced. This flavour, which is well known to all cider makers, is generally attributed mainly to decomposition products derived from the dead yeast cells. It is probably also due in part to products arising from the destruction of malic acid by certain types of bacteria, since it is always present when a considerable drop in acidity has taken place. This undesirable " old " cider flavour was completely absent in the cold stored samples.

In the cases of the ciders with low acidity, made exclusively from sweet and bitter-sweet varieties of apples, the difference in flavour between the low and higher temperature samples was not nearly so marked.

Colour.

The colour of the cold stored samples was uniformly better than the colour of the corresponding samples kept at ordinary temperature. The former had maintained the bright amber tint typical of newly made ciders, whereas the control samples were paler with a characteristic dull, almost greyish tinge, much less attractive to the eye.

Acidity.

The percentage of malic acid in the samples kept in cold store remained practically unaltered during the storage period, but the samples kept at ordinary temperature showed a general decrease. In several cases this decrease was very appreciable, as much as 33% of the original acid having disappeared.

It was especially the ciders with an acidity of over 0.4% that showed a marked decrease in acidity. The following two cases may be quoted as examples :—

Cider No. 127, cold store 0.47% malic acid ; ordinary temperature 0.31% malic acid.

*Cider B.*1, cold store 0.49% malic acid ; ordinary temperature 0.32% malic acid.

Specific Gravity.

The specific gravities of the ciders kept in cold store remained practically unchanged during the storage period. In the case of the ordinary temperature samples there was a loss of gravity varying from 1 to 4 points during the eight months.

With regard to effervescence, the samples kept at the highest temperature showed, as was to be expected from the gravity change, more effervescence than the cold stored samples. Some of them had in fact developed too much gas. The cold-stored samples had, with the exception of 3 out of the 36 ciders, adequate gas development to produce a suitable degree of effervescence : the three exceptions were too still for an ideal bottled cider.

Deposit.

When the tests were started, all the ciders had already been in bottle for 4-5 months. They were bottled direct from the filter at the time of filtration, when the respective ciders stood at specific gravities varying from 1.025 to 1.030. Consequently a small deposit was present in all cases at the start of the test.

After the eight months storage this deposit had not increased in the case of the low temperature samples, as practically no yeast growth and consequent drop in specific gravity had taken place. All the samples kept at cellar temperature showed, on the contrary, increased deposits and, as already stated, the consequent corresponding drop in specific gravity.

A microscopical examination of the deposits showed a distinct difference between the two sets of samples. In the case of the cold stored samples the yeasts were predominantly of normal appearance and few torulae and bacteria were found. The deposits in the ciders stored at the higher temperature showed abnormally elongated yeast cells and much more development of torulae and bacteria.

Conclusions.

The results of these tests clearly warrant the general conclusion that the storage of cider at 1 °C. over a prolonged period, causes a sufficient check to the various processes associated with the ageing

of ciders to retain the beverage in substantially the same condition as when it was placed in cold store. The beverage at that temperature evidently undergoes little chemical change and the development of micro-organisms is insignificant. Consequently the condition of the cider is practically stabilised so long as it remains at that temperature and, so far as the bottled article is concerned, no material formation of deposit or flavour deterioration need be apprehended.

By making use of low temperature storage, therefore, the cider maker or bottler can keep his market supplied with an article of practically constant character over a period of at least twelve months. He can retain the fresh fruity flavour of the apple, the pleasant acidity, and the bright colour of the newly made article and he can at any time produce a bottled article with all necessary effervescence and with a negligible amount of deposit. Under ordinary temperature conditions of storage he cannot produce—except by the use of champagne methods—a naturally conditioned bottled cider offering those advantages after the cider has been in bottle some three or four months. A longer period in bottle generally involves progressive deterioration in quality and progressive reduction of market value. Not infrequently a stock of cider bottled in spring is so disfigured by deposit by the following autumn as to be unsaleable at a reasonable price and it has to be rebottled or removed from bottle and treated as draught cider, with consequent material financial loss.

Corresponding advantages doubtless attach to the storage of cider in bulk at low temperatures.

It would appear, therefore, that the economics of storage of cider at low temperatures are, *prima facie*, worth detailed investigation and it is proposed that this matter should be more closely examined at the Institute during the coming season.

SOME TRIALS WITH NEW TYPES OF CIDER FILTERS.

By O. Grove.

The introduction of pulp filters into the cider industry in the later years of the last century marked the beginning of a new era in cider making. Filters of that type made it possible to produce with relative ease a clear cider at almost any stage in the fermentation of the juice and consequently to control or arrest fermentation at will, retaining much or little of the natural sweetness as desired. The filtered liquor was not rendered absolutely germ-free, both yeast and bacterial cells passing through the filter in limited numbers. Hence both renewed alcoholic fermentation to a mild degree and bacterial disorders could arise afterwards.

Since the time of their first introduction various improvements in constructional design of these filters have been made, but no fundamental difference in the character of the filtered liquor has resulted. Invaluable as the pulp filter has proved to the cider maker, its inability to furnish a germ-free filtrate is a point of weakness for modern requirements. The public demand, where bottled cider is concerned, is for a brilliantly clear, non-deposit article, free from liability to disorders developing after bottling. To meet these needs other types of filters based on different systems of filtration have been tried from time to time without much success. Recently, however, two new types have shown more promise, and the following notes on trials carried out with them at the Institute during the past year may prove of interest to cider makers.

The Seitz Filter.

In one case the machine is a relatively new type of filter of German manufacture. The filtering material in this filter consists of hard pressed discs made in a special way from a mixture of cotton and fine asbestos threads. This material is packed so closely together that the pores through which the liquid passes are so minute, according to the makers' claim, that yeast cells and bacteria cannot pass. Consequently, the filtered liquid is reported to be completely free from micro-organisms. The trials carried out at the Institute show that this claim is substantially correct.

The filter is similar in construction to the ordinary filter press. The filtering pads are inserted between tinned metal plates provided with filtering gauze and the whole filter is screwed up tightly. Before starting to filter it is sterilised by passing steam through at low pressure (5 lbs.). The steam enters at the outlet pipe of the filter and leaves by the inlet. Afterwards a little clean water is pumped through to rinse the filter.

The cider which is to be freed from micro-organisms should first be filtered bright by means of an ordinary pulp filter and should be as clear as possible. Naturally, if it is attempted to pass cloudy cider directly through the special filter plates, the fine pores of the filtering material will become blocked up very quickly and only a few gallons of liquor will pass through before the discs get completely closed. With the small filter with twelve filtering discs used for the trials here it is possible to filter 150-200 gallons before it is necessary to change the filtering discs. These cannot be cleaned, so they have to be replaced by new ones at each change.

In passing through the filter the cider loses all its natural gas. As all the yeast cells are eliminated no fermentation takes place subsequently. If the cider is wanted for bottling and it is desired that it should be in sparkling condition, it is necessary to carbonate it artificially, since no natural after-fermentation can take place in bottle. For this purpose a carbonating cylinder and a bottle filler are necessary as adjuncts to the filter.

The cider leaves the filter in a sterile condition, as already stated. To prevent contamination afterwards certain precautions have to be taken. If the cider is bottled immediately after filtration, the connecting tubing, carbonating cylinder and filter should be sterilised before the cider enters. This can be done by steam, but if that is not convenient, sterilisation may be effected by means of a 2% solution of sulphur dioxide, which is passed through the whole apparatus. The bottles, after cleaning in the usual way, are also rinsed out with a 2% solution of sulphur dioxide, and the corks are soaked for some time in the same solution.

The following experiments have been carried out with this filter.

1. To a Sweet Alford cider was added some concentrated apple juice, a little sugar and ammonium phosphate together with small quantities of lees from several casks of different ciders. At the same time there was also added a fresh culture of the cider-sickness bacillus, some bottles of ropy cider and some acetified cider. The test cider was prepared in this way to give the different disease-producing organisms good growing conditions. The mixture was

filtered and bottled and the bottles placed at different temperatures (60-75 °F.). After storage for about one year none of the bottles showed any micro-organism growth ; the cider was perfectly clear and sound.

2. From a cask of cider 6 gallons were filtered every six weeks during the summer and bottled in two lots with and without addition of sugar. Controls bottled direct from the cask were taken in all cases. None of these samples showed any deposit six months after bottling, whereas the control samples all had yeast deposits.

Besides these two sets of experiments several casks of Kingston Black cider and a cider made up from 16 different varieties were bottled after filteration through this filter. In these cases also no deposit appeared as a general rule, but all the controls filtered in the usual way through a pulp filter before bottling produced fairly large deposits. In one or two cases where a slight deposit occurred in the specially treated ciders after prolonged storage, this result was attributable to the filter discs being subjected to too high pressure.

It can consequently be concluded that it is possible by means of a filter of this description to eliminate all the micro-organisms, yeast and bacteria present in the cider, so that no after growth takes place in the bottles and the cider keeps perfectly bright for any length of time.

With the public demand for completely bright, deposit free ciders in view, the advantages of this filter are apparent. It is possible to deliver the cider perfectly bright, and there is no danger of complications in the way of deposits or the development of disorders.

Its disadvantages are, firstly, that it is necessary to carbonate the cider artificially, if a sparkling cider is wanted ; secondly, that there is extra cost involved ; and last, but not least, that no " maturing " takes place in the bottles, the flavour remaining rather " new."

With regard to the first point, the addition of carbonic acid gas to cider is already a common practice, but the effervescence produced in this way does not compare favourably with the effervescence resulting from a slow fermentation in the bottles. It might be possible to remedy this by the addition after the filtration of a culture of pure yeast in limited quantity, so that only a very small deposit would be produced, and in this way a mixture of natural and artificial effervescence obtained. Experiments on

these lines will be carried out on the new season's ciders. This pure yeast treatment would undoubtedly have a beneficial influence upon the development of flavour at the same time.

With regard to the cost this can be estimated at about 5 - per 100 gallons for the filtering discs without taking the extra labour into consideration.

The Metafilter.

Recently some further trials of a preliminary character have been carried out on a small scale with a laboratory model of another new type of filter called the Metafilter. This filter works upon a new principle. Instead of filter-pulp, asbestos, filter-cloth, or similar material as the principal filtering medium, this filter has one or more sets of specially constructed thin metal strips, which are placed in layers and pressed together, so that very fine slits are formed between the individual strips. The cider to be filtered has first added to it a little Kieselguhr or finely powdered charcoal, which, when the liquor is forced against the metal filtering surface, forms a filtering bed by partially filling up the slits.

The results obtained with this small filter were not sufficiently conclusive to give a definite opinion as to the value of the system for producing a filtrate free from micro-organisms. Unfortunately, a larger filter was not available at the time. It is hoped soon to be able to give this type of filter a trial on a factory scale.

Filters of the two types mentioned should be particularly useful in the cider industry for producing a completely deposit-free cider without having recourse to the expensive champagne process, and also for making non-alcoholic beverages with apple juice as a base.

THE PREPARATION OF WILLOW RODS FOR INDUSTRIAL USE BY DECORTICATING MACHINERY AND ITS ECONOMIC SIGNIFICANCE.

By H. P. Hutchinson.

Introduction.

Since the inauguration of the Ministry of Agriculture's Willow Development Scheme in 1922, investigations of various factors which operate in the production of peeled willows have been carried out at the Research Station, Long Ashton, with results which can be recommended to growers as improvements in their methods of treatment of rods in the stages immediately prior to their decortication.

The actual process of peeling itself being mechanical, any useful practical developments in its methods would involve the use of machinery. Hence, any research work undertaken with this in view would come primarily within the province of the Engineer and Machine Constructor. Biological factors are, however, concerned in the process, and for this reason, together with the fact that the Willow Research Officer has been frequently and urgently pressed for help from the willow growers, the subject has received some attention at this Station. As an outcome improvements in the present hand-breaks and simple mechanical aids have been devised.

The transition stage in the methods of willow peeling which has now been reached as a result of the invention of an efficient new type of peeling machine, much in advance of those previously constructed, affords a suitable opportunity for reviewing the subject, and of considering the prospective, immediate and future effects which the innovation appears likely to have on the willow-growing and basket-making industries.

The various methods of treatment of willow rods as preparation for peeling either as "White" or "Buff," have been described previously in sufficient detail for the processes to be understood (1, 2, 3).

Financial Considerations in the Present Condition of Willow Peeling.

On the matter of costs of production, the preparation of rods (either for "White" or "Buff") prior to their being peeled is of

secondary commercial importance in comparison with the costs of the operation of peeling itself. Ninety per cent. of the total costs incurred in peeling is absorbed as peelers' wages.

The wages paid to peelers at the present time are low, considered from the point of view of costs of living, but in spite of this fact, the total costs of peeling amount to between £8 and £10 per ton, largely due to the slow rate at which the hand work can be performed.

In willow growing areas a shortage of peeling labour began to be experienced by the growers before the outbreak of the Great War, not so much on account of the wages paid for the work as to the fact that the younger generation of workers regarded peeling as low class labour and sought other occupations as being of a more agreeable character. During recent years the difficulty has become greatly intensified. The reduced number of peelers has been able to make demands from the employers to which the latter have been compelled to comply. As an example of this it may be stated that it was customary for the peelers to strip the willows on the employers' premises. Under this system the rods were conveniently at hand and the work was carried out under supervision at day wages or at piece work rates. At the present time the workers find it more convenient to peel at their own homes and the employer is compelled, therefore, to distribute and collect the rods, sometimes over a distance of several miles. In addition to extra costs on the process which these journeys incur, other losses due to carelessly peeled rods and waste frequently occur.

Development of Willow Peeling Machines.

Until the present time the willow industry has missed the benefits which invention has brought to other national industries, probably because willow growing is only very remotely allied to other branches of agriculture and does not appear to offer sufficient attractions to the inventor.

For many years, the value of a machine which could be used to expedite and reduce costs in peeling processes has been realised in all countries where willows are grown, and frequent attempts have been made by enthusiastic growers to supply this want. During the last 50 years several machines have been constructed and patented with little success, as far as English efforts are concerned. The first machines to be constructed were merely multiples of the hand-breaks then in use and were so devised as to enable several rods to be simultaneously treated. The heavy work on the operator which they necessitated debarred them however, from coming into general use. At a later date pulling devices were suggested

but the results were not satisfactory. A step forward was made about 1890 in the construction of machines involving a new principle in their working. Departing from the old fashioned break method, rollers with rough surfaces working in conjunction with scrapers were designed, the idea being that the rollers in carrying the rod forward would dislodge the bark sufficiently to enable the scrapers to clear it from the wood. When tried, it was at once obvious that the pressure necessary to draw the rod forward and at the same time loosen the bark caused damage by fracturing the wood. Further serious damage was experienced in dealing with the bark which clogged the machines.

In recent years the advantages which a satisfactory peeling machine would confer on the willow industry have been more fully realised by foreign inventors, and the machines which have been constructed on the Continent and in America have been so much in advance of older types as to justify the view that the problem was rapidly approaching the stage when the difficulties which former workers had experienced would be solved. The machine invented and constructed by Cermak (Czecho-Slavakia) in 1920 exploited more fully than similar working machines of former makers the possibilities of the use of rollers in effecting decortication, and at the time of its invention marked the most advanced stage reached. Essentially, the peeling operation was performed by four pairs of finely grooved metal rollers working in series. The motion of the rollers was rotatory for carrying the rods forward and simultaneously laterally, whereby, by friction, the bark was detached. The machine was power driven and the rods fed singly by hand. Potentially it was capable of treating 100 rods or more per minute, but its capabilities were limited by the speed at which the feeder was able to introduce the rods. Satisfactory work was done when hard-wooded varieties of willows and sticks of two or more years' growth were treated. Although the pressure of the rollers could be regulated by controlled springs it was found impracticable to peel soft-wooded varieties and rods less than 4 feet in length, owing to the splitting which occurred when sufficient pressure for bark removal was applied to the rollers. The machine created much interest amongst English growers, but was not accepted by them (except in the case of one large firm which purchased two machines) on the grounds of costs, complicated construction, and inability to deal with rods of any variety and size.

The Rouy and Masson Peeling Machine.

The problem now appears to have been satifactorily solved by French inventors, who have received considerable support from the French Government through its Institution, L'Ecole Nationale

d'Osierculture et de Vannerie, Fayl-Billot, Haute Marne and La Chambre Syndicale des Osiéristes Français. Since the foundation of the School in 1905, encouragement has been given towards securing general improvements in the willow growing and basket making industries, particularly with respect to the difficulties attending the hand peeling processes. Competitions of machines brought forward at various times were arranged periodically. In May, 1929, at the annual demonstration held at Fayl-Billot, six firms competed. Of the two machines showing particular merit, the one invented and constructed by Messrs. Rouy and Masson, Marainvillers, was most favoured by the judges. The makers received the Award of Merit and won the Silver Medal awarded by the French Ministry of Agriculture.

The favourable reports which appeared in the French Trade and Scholastic Journal "Osier-Vannerie" suggested the advisability of bringing the machine to the notice of the growers in this country. Arrangements towards this end were made between the inventors of the machine and the Research Station, Long Ashton, and resulted in a public demonstration being given at Stoke St. Gregory, Somerset, on November 5-6, 1929. The attendance, (approximately 300), which included representatives from all the chief willow growing districts in England, provided evidence of the importance with which the subject was regarded. Boiled rods were used and the peeling of these was unanimously considered to be satisfactory. The English agency for sale of the machine was secured by a local firm and several machines were immediately sold.

The machine is simple in construction, consisting merely of rows of breaks mounted on an axle. It embodies the important new principle of moving breaks acting on willow rods kept stationary, whereas all older types were constructed on the principle of moving rods being carried through fixed breaks or rubbing surfaces.

The breaks project through openings in a metal cylinder having a diameter of about 24 inches. The axle works on bearings and is fitted at one end with a driving wheel. A $1\frac{1}{2}$—2 H.P. engine provided sufficient power for the work.

Peeling is effected in the following way. The machine is adjusted to run at a speed of 250 - 300 revolutions per minute and the operator then places a handful of rods on the cylinder, butts forward. The basal portions of the rods are caught between the jaws of the breaks as they revolve and are held in this position until all the bark has been removed. The rods are then withdrawn, reversed,

and the upper portions similarly treated. The rate of peeling is approximately eight times that of a good hand peeler. The machine also possesses the following additional advantages :—

1. The number of split or otherwise damaged rods is much less than in the case of hand peeling.
2. Rods of any size are equally well peeled.
3. Working under cover, peeling can be carried out under weather conditions which would stop hand peeling.
4. The labour involved is light, a youth being able to do the work with ease.
5. The machine should have a long life : it withstands wear and tear well, and broken or worn parts are easily replaceable.
6. The price is moderate and not greater than a grower of about 10 acres of willows should be able to afford.

At the present time the machine is offered by the makers in two sizes, the smaller for single and the larger for two workers. It is probable that improvements will be added as experience is gained, possibly in the directions of increase in size so as to make fuller use of the power provided, and by the introduction of some form of mechanical feed. It is apparent, however, that the machine in its present form works with great efficiency and its use will affect considerably the willow growing and basket making industries.

The total costs of peeling have not yet been ascertained, but the following comparison with hand methods may be made.

Costs of Producing 10 *tons of Peeled Rods.*

By hand	Wages of 8 peelers	£80
By machine	„ „ 1 operator	£10

If to this latter item be added the proportion of purchase price, costs of engine power, depreciation, repairs and interest on capital outlay, a substantial balance should be left in favour of the machine.

On these data, it may be accepted that in the peeling of 10 tons of willows, *i.e.* the crop of 7-10 acres, the total initial costs of purchase of the machine would be fully met, all further quantities of willows peeled during its lifetime, (probably 10 years), being produced at a cost of not more than £2 per ton.

Effects of Efficient Peeling Machines on the Industry.

The use of efficient peeling machinery will have serious effects on rural wages in willow growing centres. Hand peeling may linger for a few years in the cases of small growers and where hand peelers are prepared to work for very low wages, but peeling by machinery will become the general practice.

By lowering the costs of production of peeled rods the basket making industry might be benefited and, with increase in the production of basketry, an increase in the acreage of cultivated willows should follow. This view would be affected, however, by the fact that foreign competitors in willows and baskets, possessing the machine, would have similar advantages to English producers since, in addition to its being used in France, the machine has already been introduced into Belgium, Holland, Germany, Austria, Poland and Spain.

The main value of the invention is in the trade advantage which it may give to the basket-making industry in all countries, by enabling the basket makers to compete successfully against basketware for the manufacture of which cane, wood and other basket-making material is now used.

REFERENCES.

1. The Cultivation of Osiers and Willows. (*Ministry of Agriculture and Fisheries*) *Miscellaneous Publication No.* 18.

2. The Cultivation of Osiers and Willows by W. Paulgrave Ellmore. (*Dent and Sons*).

3. Annual Reports of the Agricultural and Horticultural Research Station, Long Ashton. 1923 to 1928.

REPORT ON ADVISORY WORK, 1928-29.

As has been the case each year since the war, a new record for the number of enquiries received has again been set up during the year under review. Recent years have shown a progressive diminution in the rate of increase of enquiries, but this year there has been a notable advance in numbers. This has occured almost entirely under the heads of " Economic Entomology " and " Cider." The increase in the former case is accounted for by the large number of enquiries received with regard to the recent Long Ashton work on Tar Distillate sprays. In the latter case the work under the Cider Instruction Scheme is evidently responsible.

The following table gives the numbers of enquiries submitted during the last six years.

	Year ending September 30th.					
	1924	1925	1926	1927	1928	1929
Gloucester (including Bristol)	137	194	262	183	202	193
Hereford	107	88	91	115	97	115
Somerset	130	395	276	254	308	300
Wiltshire	24	117	175	104	104	139
Worcester	78	78	103	168	161	136
Other Areas	195	222	309	478	495	721
	671	1094	1216	1302	1367	1604

Included in the figures under " other areas " are enquiries received from Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute, and from Dorset, which participates in the Scheme for Local Instruction in Cider-making. None of these counties rank officially as part of the Bristol Province.

This list does not indicate the very numerous enquiries dealt with in personal interviews during survey work, local investigational work, shows, etc., nor those relating to fruit and vegetable preservation and products, which are dealt with by the Campden Station. Also, as in previous years, no figures for enquiries received under the heads of Agriculture, Economics or Dairy Bacteriology have been included, in order that the statistics given may be comparable with those of earlier years before those subjects were dealt with.

Certain items of the work during the year call for special mention.

There was a reference in last year's report to the introduction into the Longleat experiment of certain treatments suggested by local farmers. This was rendered possible by a grant from the Bath and West and Southern Counties Society. Until the season 1929, no manures at all had been used on those plots, and the experiments had been confined to testing the value of more "intensive" management, *i.e.* controlled grazing, harrowing and trimming. The results in 1928 indicated a very definite improvement due to intensive management. During the season 1929, manuring both with mineral and nitrogenous fertilisers has been introduced on certain plots.

As a result of additional small grants from the Ministry of Agriculture in respect of (*a*) farm accounting in Gloucestershire and (*b*) cost of production of sugar beet, it has been found possible to extend the Agricultural Economics investigations into all five counties of the Province, and the Agricultural Economist is now in touch with one or two of the Worcestershire farms specialising in fruit and vegetable culture.

Attention may be drawn to the gradual broadening of the scope of the work of the Dairy Bacteriologist, who a year or two ago dealt with very little work other than so-called "clean milk" work, but who has recently been drawn into other types of investigations, especially one in connection with taints in cheese.

After a year's trial, the value of the Wiltshire Register of Accredited Milk Producers is gradually showing results. It would appear to be an excellent supplement to a county Clean Milk Competition and forms the basis of some valuable advisory work as well as investigational work.

The scheme for local instruction in Cider-making continues to develop satisfactorily, and the work of the Instructor is resulting in marked improvements in the quality of cider produced by farmer cider makers in all the counties concerned. In Dorset, the Dorset Farm Cider-makers Federation was formed during the year, and the Instructor is co-operating with this Body in the production of bottled cider.

Advisory work in Cider-making again shows an increase, and the number of enquiries received from Overseas—52—is notable.

The need for an Adviser in Pomology becomes more urgent each year since enquiries from growers, often relating to subjects involving personal visits to farms and of a time-consuming character, continue to increase.

As stated previously, there has been a marked increase in the enquiries under Economic Entomology due to the recent Long

Ashton work on tar-distillate sprays. During the year, the Adviser concerned and the Research Entomologist of the Institute carried out an extensive series of field trials with the new form of tar-distillate wash evolved at Long Ashton. These trials have shown conclusively that the new wash provides a means of controlling Apple Capsid in the egg stage, and this accomplishment may be ranked as one of the most notable advances in the control of insect pests made in recent years.

The Adviser in Economic Mycology is giving special attention to diseases of market garden crops, a subject of great importance in the Province. A survey of the more serious diseases occurring in the Evesham market garden area has been made and, as a result of this, investigations have been commenced on the so-called asparagus "sickness" and on certain root rots of dwarf beans and peas.

Reference was made in the previous report to the establishment of Variety Trial Plots of Willows in the centre of the Somerset Willow-growing Area. These plots have attracted much attention in that area, and promise to be of great value to the industry. Three varieties supplied by the Long Ashton Station for trial on the plots—Harrison, Grizette and Whissender—have shown special merit and cuttings of the variety Harrison have been distributed amongst local growers.

The subjects covered by the Advisory work of the Department are Agriculture, Agricultural Chemistry, Agricultural Economics, Dairy Bacteriology, Cider and other Fruit Products, Fruit and Vegetable Preservation, Pomology, Horticultural Chemistry, Economic Entomology, Economic Mycology and Willow Growing. The salient features of the work under each of these during the year are summarised below.

Agriculture.

The main feature of the work in Agriculture, as in previous years, was in connection with grass land improvement. In addition to experimental and advisory work on this subject within the Province, the Chief Advisory Officer, who is responsible for the work, has again taken an active part in grassland schemes in other parts of the country.

Agricultural Chemistry.

205 requests for advice were received and 897 samples were analysed in connection with these enquiries.

The main investigations in progress were as follows :—

Grass Land Improvement.

1. Analysis of grass samples from experimental plots in connection with the Longleat Intensive Grazing Plots, and plots under the Cambridge Pasture Experiments Scheme.
2. Variety trials of strains of Rye Grass and Cocksfoot.
3. Eradication of Black Grass (*Alopecurus agrestis*).

Arable Land.

1. Persistence of strains of red clover.
2. Sugar Beet—Analysis of samples under the Provincial Manurial Scheme, and the Regional Prize Scheme. Experiments on the storage changes which occur in Sugar Beet.

Land Drainage. Effect on soil texture.

Destruction of Moles. Experiments with Red Squills (*Scilla Maritima*), Cyanogas and Horogas.

Feeding Stuffs. Cases of alleged poisoning of stock.

Agricultural Economics.

The Adviser in Economics has now extended his activities into all five counties comprising the Bristol Province, and he is in touch with accounts relating to all branches of Agriculture, including market gardening and fruit growing, represented in the counties.

Investigations in progress during the year may be summarised as follows :—

Costing. These investigations are in progress on 11 farms, comprising 2,566 acres, of which 6 are mixed farms, 3 mainly grass, 1 market garden and 1 fruit.

Financial Accounts. 180 farms, comprising 80,768 acres, are included in this work. They are classified according to (*a*) percentage of permanent grass, (*b*) types of produce.

Cost of Production of Sugar Beet. In conjunction with the Agricultural Research Institute, Oxford, the costing of sugar beet production was carried out on 40 farms, embracing 532 acres.

Dairy Bacteriology.

469 samples of milk were examined in the course of advisory work, and a total of 3,422 samples in connection with the whole of the activities of the Dairy Bacteriologist.

Clean Milk Competitions. The Department co-operated with the various counties concerned in connection with the undermentioned clean milk competitions.

Somerset. Competition confined to cheese-makers, of four months duration, commencing April 1st.

Gloucestershire. Three classes for competitors, of three months duration, commencing January 1st.

Worcestershire. Two classes for competitors, of six months duration, commencing January 1st.

Wiltshire. Two classes for competitors, including one for Open Air Dairies, of six months duration.

Register of Accredited Milk Producers. This register was commenced in Wiltshire for an initial period of 12 months, in January, 1929, and has provided an excellent means for the Dairy Bacteriologist and the County Officers maintaining touch with milk producers after the close of the county clean milk competitions.

Dairy Conference. A conference on dairy problems, arranged by the Department, was held in the University, on Thursday, April 25th, when papers relating to the Dairy Industry were read by members of the Advisory Staff.

Cider and Other Fruit Products.

445 enquiries, including 154 under the Cider Instruction Scheme in the counties of Dorset, Monmouth and Worcestershire, were dealt with.

Special attention was paid to the following points by the Instructor in the above-mentioned counties :—

Bottling of Cider. Experiments were carried out in all the three counties, in an attempt to stimulate the production of high-grade bottled cider on the farm.

Filtering. Since filtering is essential to the production of good bottled cider, demonstrations of filtering methods have been given.

Disorders of Cider. Several cases of "Sickness" and "Ropiness" of cider were investigated.

Trial Orchards. Records relating to growth characters and cropping were taken in certain of the County Trial Orchards, and a new Trial Orchard was established at Solway Ash, nr. Bridport, Dorset.

Fruit and Vegetable Preservation.

Advisory Work. As the result of the somewhat rapid development of commercial canning, there has been a marked increase in the number of enquiries received at the Campden Station. Of the 523 enquiries dealt with, 307 were of a commercial nature. The Station has been visited during the year by representatives of practically the whole of the firms canning fruit and vegetables in England, and many visitors from various parts of the Empire have also been shown over the Station.

The enquiries were chiefly in connection with technical problems relating to the canning of fruit and vegetables. The canning of peas has received marked attention from commercial firms during the year, and in addition to several firms who canned this product for the first time during the year under review, there are three factories in course of erection which will be canning peas during 1930.

A research exhibit was staged at the Third Annual Canners Convention held at Cambridge on the 25th, 26th and 27th June, and the canners showed marked interest in the exhibit. The Acting Resident Director addressed the Canners on "Modern Processing Methods in Fruit Canning," and this gave rise to an interesting debate on the strengths of syrup which should be used in the canning of English fruits.

The Station had a canning exhibit at the Imperial Fruit Show which was held in Birmingham towards the end of October, and many different varieties of strawberries, raspberries, and plums, which had been canned during the summer were on view. The canning variety trials proved of great interest to growers, and many of them offered to send varieties for test during the coming season.

Educational Work. That the interest in fruit preservation in the home has been well maintained is shown by the sale of leaflets covering the preservation of the various fruits and vegetables, and of which some 7,000 have been sold during the year.

Five courses of instruction in fruit and vegetable preservation were given at Campden during the period from June 25th to August 30th, and the courses were booked to their full capacity. The students comprised teachers and students of domestic science, Women's Institute members, dairy instructresses, horticultural lecturers, housekeepers in large institutions, lady gardeners, and private individuals.

A special course arranged for Women's Institute demonstrators was held immediately after the usual courses. The students—of whom there were six—had previously been to Campden for a ten-days' course. The two-day Refresher Course was devoted principally to the consideration of the best methods of imparting knowledge to Women's Institute members, and to judging at Produce Shows.

Judging of jams, jellies, bottled fruit, and pickles, etc., was carried out at the following Shows :—

Gloucestershire W.I. Produce show.
Worcestershire W.I. „ „
Derbyshire W.I. „ „
Mickleton (Group) W.I. „ „
Worcestershire Root, Fruit, Grain and Flower Society.
Gloucestershire Root, Fruit, and Grain Society.
Warwickshire County Federation of W.I's. Show.

At many of these shows, in addition to judging, lectures were given on the canning and bottling of fruit, and a small exhibit of bottled fruit was displayed.

On the invitation of the Principal of Radbrook Technical School for Girls, Shrewsbury, a lecture on jam-making was given to forty teachers of domestic science who were attending a Refresher Course.

Lectures were also given at the Hertfordshire Farm Institute, Bangor Normal College, North Wales, and to several Women's Institutes.

Special Investigations. During 1929, the Campden Station has continued its work in connection with the problems of fruit and vegetable preservation in this country. The principal subjects of investigation have been concerned with the rapidly developing canning industry, and the investigations have been carried out largely with a view to assisting growers and commercial canning firms in improving the quality of English canned frut and vegetables.

The chief subjects studied during the year include :—

1. A large number of experiments on the causes of the corrosion of tinplate by fruit acids.

2. The canning of the various types of English fruits in sugar syrups of different strengths, and the determination of the relationship existing between the final density of the syrup in the can, and the original proportion of the solid and liquid contents.

3. The suitability of various varieties of fruits and vegetables for canning.
4. The use of the vacuum sealing process in fruit canning.
5. The determination of minimum sterilization times for the different fruits and vegetables.
6. The preparation of fruit syrups, fruit purées and juices, concentrated under vacuum for use as natural fruit flavours in soda fountains, ice creams, chocolate centres, etc.
7. The preparation of dessert fruits in brandy.
8. Extensive tests on the canning of green vegetables.
9. The use of food colours.
10. Analyses of fresh fruits.

Pomology.

166 enquiries under this head were received.

The main research activities in this subject, in connection with advisory problems, were as follows :—

1. A pomological survey in conjunction with soil survey work in the Evesham-Pershore area of Worcestershire.
2. Sub-soiling investigations in Worcestershire in connection with the bad effects of impervious sub-soils and hard pan on the growth of fruit trees.

Horticultural Chemistry.

93 enquiries, including 43 from centres outside of the Bristol Province, were received.

Investigations were in progress on the following points :—

1. Manuring of fruit trees, bush fruits and vegetable crops.

   The experiments on the two former had special reference to the use of Potash and Nitrogen. In the vegetable experiments, the trials were in connexion with asparagus "sickness."

2. Survey of soils in fruit and market garden areas on the Lower Lias formation.

   Survey work was continued in the Evesham and Pershore areas.

Economic Entomology.

355 requests for advice, including 169 from areas outside of the Bristol Province, were received. The large number from areas outside of the Province related chiefly to the use of tar-distillate sprays and strawberry troubles, subjects which have been specially studied by the Adviser.

The main investigations carried out were as under :—

Tar Distillate Sprays. Extensive field trials with the new Long Ashton wash were carried out under a special grant from the Ministry of Agriculture and Fisheries. The trials proved conclusively that this wash provides an efficient control against the Apple Capsid as well as Caterpillars, Psylla and Aphis.

Pear Midge. Experiments on the control of this pest were vitiated owing to frost damage on the blossoms of the trees. The control treatments applied were :—

a. Soil treatment with Calcium Cyanide.

b. Soil treatment with Tar-distillate Washes.

c. Spraying at blossoming time with nicotine and soft soap.

Woolly Aphis. A further attempt to control this pest by the parasite *Aphelinus mali* has been made in an orchard near Bristol.

Strawberry Problems.

Red Spider Damage. Further Survey work was carried out to examine the effects produced by red spider (*Tetranychus telarius*) on strawberry plants. The pest appears to cause a " small leaf " type of plant.

" Red " Plant. Experiments were continued to elucidate further the relationship of eelworm to this disease.

Control of Market Garden Pests by means of Naphthalene. Experiments on the use of naphthalene for the control of *Psylliodes chrysocephela* on young brassicae, *Psila rosae* on celery and *Blanjulus* sp. on potatoes showed that these pests can be controlled by this substance.

Economic Mycology.

The number of enquiries received during the year was 161. The chief subjects of investigation were as follows :—

1. *Diseases of Fruit Trees.* Field control of apple mildew and apple scab ; field studies on plum rust, raspberry mosaic and " yellows," over-wintering of the black currant rust fungus (*Cronartium ribicola*), transmission of " red " plant of strawberries by the aphis, *Capitophorus fragariae.*

2. *Market Garden Crops.* A Survey of diseases of market garden crops in the Evesham area was made. Special investigations were carried out on asparagus " sickness," a foot rot of dwarf beans and of peas, potato " sickness," mosaic of vegetable marrows and potato " blight " with special reference to effect of age on resistance to "blight."

3. *Hops.* A Survey of hop diseases was carried out. The incidence of " Downy " mildew was found to be slight, but " nettlehead " and " mosaic " were of importance.

4. *Ornamental Plants.* Experiments were carried out on the control of " damping off " of Begonia seedlings, and of Carnation rust.

5. *Willows.* *Melampsora* rusts of willows were studied.

Willow Growing.

169 requests for advice were received, and of these 84 were from areas outside of the Province.

The main subjects under investigation were as follows :—

Yields and Size of Willow Rods in the Somerset Willow Area.

This investigation has been undertaken as the result of numerous enquiries from growers.

A survey of the problem has been made, and experiments have been initiated, to determine how far the condition is due to soil exhaustion and to lack of control of insect and fungus pests. The question of varietal characteristics is also under examination.

County Trial Beds in Somerset. Preliminary cropping results have demonstrated the value of the varieties Harrison, Grizette and Whissender in the area.

REPORT ON OX WARBLE FLIES AND THEIR CONTROL.

By R. C. Gaut and C. L. Walton.

This article is concerned with a series of field experiments on the control of Ox Warble Flies, initiated by the Agricultural Education Sub-Committee of the Worcestershire County Council, under the chairmanship of Mr. F. Paget Norbury. In view of the serious loss due to these pests suffered by the farmers of that county, experimental work on their eradication was begun in the Teme Valley in 1928, and a carefully supervised series of field experiments was carried out during 1929. The assistance of an entomologist w th prior experience of this pest being required for collaboration with Mr. R. C. Gaut, County Agricultural Organiser, in the organisation and execution of the experiment, the services of the research entomologist of the Institute were placed at the disposal of the county, which forms a part of the Bristol University Province under the Agricultural Advisory Scheme. A detailed account of the work has been published elsewhere, (see below), by the two authors thus concerned, but in view of the association of the Institute with the work in the manner indicated, and of its general interest to agriculturists of the Province, the following resumé is included in the present Report.

Before proceeding to a description of the Worcestershire experiments, a few notes on the pest itself and previous attempts at its control are called for.

The Flies and Their Activities.

The damage done by the two species of Ox Warble Flies—*Hypoderma lineatum* and *H. bovis*—is almost too well known to need description. It may be stated briefly, however, to include (1) injury to the hides, due to the perforation by the grubs, (2) meat spoiled by their activities, (3) minor injuries due to the entry and migrations of the young larvae, (4) loss of condition and milk due to " gadding " when the flies are on the wing.

Both species may be present in any given district or one may predominate. Both are large, hairy flies which are active only in fine sunny weather during the period May to August, *H. lineata* occurring earlier than *H. bovis*.

Eggs are deposited on the hairs of the legs and lower parts of the body, and these hatch within a few days, the little grubs boring through the skin and entering the tissues of the animal. These larvae wander through the tissues, the majority reaching the region of the gullet where they remain for a period, later migrating to the region of the back where they perforate the skin to obtain air, and inverting themselves, feed upon pus produced by bacteria from the

injured and inflamed flesh. Cysts are usually formed around these grubs which grow very rapidly and finally leave the host animal to pupate in the soil, whence the flies appear after about a month.

Previous Work on These Pests.

During the past twenty years, a very large amount of research work has been done in connection with these pests, largely directed to the elucidation of their life histories (of which a very brief outline has just been given).

Latterly, however, more attention has been directed to their control, especially in Denmark, the United States, Canada, Ireland and recently in the British Isles.

As a result an increasing amount of information has been accumulated and several feasible methods of control have been worked out.

The original idea of eradication by extraction of the grubs has been largely abandoned as being slow and painful to the animal, and sometimes productive of adverse symptoms. Washes containing nicotine, derris and other substances, and ointments, particularly those containing iodoform and derris, have been used and advocated.

Experiments in Worcestershire.

The experiments instituted were carried out on 16 farms situated near the city of Worcester and towards Stourport and Bewdley. The object was to endeavour to discover whether an effective and cheap control treatment could be found. In all, 311 cattle were included in the trials, practically all being dairy animals, on account of the ease of access to this class of stock.

The materials used and number of cattle treated were as follows :—

	Ointments.	*No. of Cattle.*
A.	Iodoform Ointment	43
	Iodoform 1 part.	
	Soft Paraffin 5 parts.	
B.	*"Warble Fly Ointment"	41
	(Proprietary Preparation).	
	Washes.	
C.	Pyrethrum + Rape Oil	53
	Containing 4 per cent. Pyrethrum.	
D.	Derris (as Polvo + Soap)	94
	Derris 1 lb.	
	Soft Soap ¼ lb.	
	Water 1 gallon.	
E.	Proprietary Preparation	56
F.	Proprietary Preparation	24

Dressings.	*Approximate Dates.*
1st	March 19th
2nd	April 15th
3rd	May 14th
4th	June 3rd
5th	June 25th (two farms only).

* Supplied by Messrs. Cooper, McDougall and Robertson, Berkhamsted, who state that it contains some of the active ingredients of derris root. They also state that they have standardised the ointment for this work by biological methods.

Method of Recording.

At the first visit, all cattle on each farm were allotted a number, and entries were made in the log-book under name or description for future indentification. The number of warbles present on their left and right sides respectively were separately counted and recorded ; the materials were then applied.

Certain animals were left without treatment and retained as " controls " ; some had warbles and others none. In all, 46 cows were so utilised, 20 of which remained entirely free from warbles throughout the season.

At each subsequent visit, counts of living warbles were taken as before and booked ; dead warbles from previous treatments were located and examined. Notes and impressions were made, and a record was kept as to the quantities of materials used with a view to arriving at the comparative cost of the various dressings.

The first dressing was applied early as it was important that no grubs should have left the cattle. The length of the warble season depends upon whether only one or both of the two species are present in the cattle to be treated and it is evident that both occur in Worcestershire.

(*a*) *Initial Infestation.* The following figures include the counts at the first visit on the 19th March and also certain other interesting data :—

Number of herds	16
Number of cattle	311
Number of warbles	1,162
Number per head (average)	3.75
Smallest total number present in one herd	18
Largest number on any one animal at one time ..	54
Cattle free from warbles throughout experiment ..	65

(*b*) *Later Infestations.* That infestation usually increases rapidly during the appearance of the earlier species and then decreases, increasing again with the advent of the later species, is shown by the figures for the control cattle given below ; the experiments, however, were not designed to examine this question critically.

Under this heading, it is convenient for comparative purposes to show how the dressings behaved in exterminating warbles, and for this purpose they have been grouped together irrespective of their partial or absolute efficiency. The 65 continuously " free " cattle have also been eliminated from the calculations.

Living Warbles : Average per Head.

	March 19th.	*April 15th.*	*May 14th.*	*June 3rd.*
On Controls ..	1.9	4.0	3.0	5.0
On Dressed Cattle	4.1	3.1	1.1	0.9

Detailed counts were made at each of the five visits, and the figures obtained are given in detail in " Report on the Demonstration and Experiments carried out in Worcestershire in 1928 and 1929," issued by the Agricultural Education Sub-Committee, in October, 1929, pps. 1-26.*

The question of the cost was also considered, and is one of the most important factors.

Results of the Experiment.

Stated as briefly as possible these are as follows :—

A. Iodoform Ointment. This, for some reason not apparent, did not give such good results as expected (judging from experience elsewhere) ; the odour also is objected to by stockmen.

B. " Warble Fly Ointment." Except for some trouble in application during the colder weather, and where the cattle had very heavy coats of hair, this method was excellent. The warble mortality was 100%, and the cost very low.

C. Pyrethrum + Rape Oil. This application also failed to give the results hoped for, and the presence of oil (in this or other dressings) was undoubtedly unfavourable in action, since it prevented the grubs (even if killed) from drying up after death.

D. Derris (As " Polvo ") + Soap. This was the most successful method employed ; the " kill " was 100% ; application was perfectly easy ; there was no objectional odour, or other drawback. The cost was low, working out at 1d. per head of stock for four dressings.

E. Proprietary Preparation. This gave a high death rate of grubs and was otherwise excellent. The cost, however, was very high.

F. Proprietary Preparation. This was less expensive than *E* and possessed good killing properties. Being oily, however, it showed drawbacks similar to preparation *C*.

Summary and Recommendations.

1. Complete eradication can only be accomplished by systematically killing the warbles in the backs of the animals before they mature and drop out alive ; at this stage they are in a specially vulnerable condition and situation, and they can be easily seen by the swellings produced.

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* Copies can be obtained from the Dept. of Agricultural Education, Shirehall, Worcester.

2. The choice of the killing agent lies between ointments and liquids ; other methods are not advised.

3. An oily ointment or liquid is of little use as it disperses too readily into the surrounding inflamed tissue and often leaves the warbles untouched. If it kills, its effect is to cause the maggots to remain plump and turgid under the swellings for quite a long time. Expressed in another way, it acts as a preservative ; this is very undesirable.

4. " Warble fly ointment " is an efficient killing agent. It can be employed for cattle that are tied up, but users should remember that it must be forced into every warble hole, which must be properly plugged. A 100 per cent. kill can be obtained if this point is carefully attended to. For cattle in yards or fields it is impracticable, and is not advised for heavily infested animals because of the labour of application and the danger of passing over some warbles without treatment. Fortnightly applications are essential.

5. Derris-soap wash has given pronounced success. For the experiments it was made up as follows :—

Standardised powdered Derris Root ..	1 lb.
Soft Soap	¼ lb.
Water	1 gallon.

The soft soap was boiled in about 1 quart of water ; after cooling somewhat it was gradually poured into the dry powder, previously placed in a small bucket or can, and mixed by means of a wooden stirrer into a " mud " ; cold water was then added to make up one gallon of wash.

The application was made with a small piece of soft cloth and applied to the warble lumps which should be thoroughly wetted. Care should be taken that none be missed (since they may appear in the neck, behind the hips, etc.). Agitate the wash frequently to prevent sedimentation.

6. The cost of the ointment or the wash is relatively very small per head of cattle in the herd. The experiments show that the average total cost of four applications under the conditions specified in the report did not exceed one penny per head for material.

During these experiments no harm was done to either flesh, hair or hide.

Farms more heavily infested would be more expensive to treat, but where a wash is used the cost does not rise in direct proportion to the number of warbles present.

7. For complete extermination with derris-soap wash cattle must be examined and dressed, if warbles are present, four times during the season at intervals not exceeding four weeks. Under Worcestershire conditions and from experience during the last two years, the periods recommended are as follows :—

First dressing	March 25th to 28th.
Second dressing	April 22nd to 25th.
Third dressing	May 20th to 23rd.
Fourth dressing	June 17th to 20th.

8. The work of mixing and dressing is simple, and striking improvement in condition was shown amongst the more heavily infested animals treated.

9. This method has been adopted by the Leathersellers Company's Warble Fly Committee as the most efficient and economical at present available, and is to be employed in numerous large scale trials and demonstrations during 1930.

PUBLICATIONS, 1929.

LONG ASHTON RESEARCH STATION.

Annual Report of the Agricultural and Horticultural Research Station in the Bath and West Journal, 1929-30.

HUTCHINSON, H. P. and NATTRASS, R. M.

"Black Canker" of the Basket Willow." (Journal of the Ministry of Agriculture, July 1929).

MARSH, R. W.

"Investigations on the Fungicidal Action of Sulphur—III. Studies on the Toxicity of Sulphuretted Hydrogen and on the Interaction of Sulphur with Fungi." (Journal of Pomology and Horticultural Science, Vol. VII, No. 4, June 1929).

STANILAND, L. N. and WALTON, C. L.

"The Long Ashton Tar-Distillate Wash: Field Experiments, 1929." (Journal of the Ministry of Agriculture, September 1929).

"The Long Ashton Tar-Distillate Wash: Field Experiments 1929—II." (Ibid., December 1929).

TUTIN, F.

"The Relation between Air Temperature and Soil Temperature at Various Depths." (Read before the Agricultural Meteorological Conference, September 1928. Published by the Ministry of Agriculture, June 1929).

WALLACE, T.

"The Utilisation of Local Supplies of Chalk and Limestone for Liming Land." (Bath and West Journal, 1928-29).

"Soil Surveys." (Ibid.)

"Investigations on Chlorosis of Fruit Trees.

II. "The Composition of Leaves, Bark and Wood of Current Season's Shoots in cases of Lime-Induced Chlorosis."

III. "A Chlorosis of Plums due to Potassium Deficiency."

(Journal of Pomology and Horticultural Science, Vol. VII, No. 3, December 1928).

"Investigations on Chlorosis of Fruit Trees.

IV. "The Control of Lime-Induced Chlorosis in the Field." (Ibid., Vol. VII, No. 4, June 1929).

"Frost Injury to Apple Trees." (Fruit Grower, March 15th, 1929, and Gardeners' Chronicle, March 16th, 1929).

"Studies in the Nutrition of Fruit Trees." (Proc. of the International Congress of Plant Sciences, 1926. Vol. 2, 1929).

PUBLICATIONS—*contd.*

WALTON, C. L.

"Ox Warble Fly." Report of Experiments in Worcestershire, 1928-29. (Worcs. C. C. Agric. Sub-Committee, October 1929).

BERKELEY SQUARE ADVISORY CENTRE.

DAWE, C. V.

"Some Notes on the Economics of Milk Production." (Handbook of the Somerset and North Dorset Milk Recording Association, April 1929).

"The Depression of Agriculture." (Proceedings of Conference of Agricultural Economics Society, June 1929).

HANLEY, J. A.

"The Formation of New Pastures." (Journal of the Yorkshire Agricultural Society, 1929-30).

LING, A. W.

"Some Pot Experiments on the Manuring of Sugar Beet." (The British Beet Grower, Vol. II, No. 6, February 1929).

CAMPDEN RESEARCH STATION.

HIRST, F.

"Modern Fruit Canning Operations." (Ministry of Agriculture's Journal, April 1929).

"The Preparation of Pickles." (Campden Reaearch Station Leaflet, No. 13).

HIRST, F., ADAM, W. B. and ADAMS, MARGARET L.

"Domestic Preservation of Fruit and Vegetables." (Ministry of Agriculture's Miscellaneous Publication, No. 69).